Financial Market Structure and Dynamics : Proceedings of a Conference Held by the Bank of Canada, November 2001

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Introduction

Charles Gaa and Peter Thurlow

The topic for this conference, "Financial Market Structure and Dynamics," was selected to highlight some current research on financial markets.[1] Most of the papers presented at the conference could be considered to be within the "market microstructure" literature. Market microstructure is a relatively new branch of financial economics that seeks to explain how latent supply and demand for financial assets are transformed into transactions, and how this process drives asset-price dynamics. Market microstructure research investigates the institutional structure of financial markets, including information distribution patterns and the resulting incentives structure faced by market participants. This, in turn, helps to explain the behaviour of the participants, the markets, and the resulting asset-price discovery process. The study of market microstructure can make important contributions to central banking, which suggests that it should be a core area of central bank research.

In the implementation of monetary policy, it is often very useful for a central bank to be aware of the market's expectations of upcoming policy developments. Consequently, the first way in which market microstructure research can support central banks is by creating a deeper understanding of how markets operate and how they react to and impound economic news and shocks.

Many central banks have long considered issues related to the stability of the components of the financial system (financial markets, financial institutions, and clearing and settlement systems). Recently, a number of central banks have taken a more integrated and focused interest in financial stability.[2] This interest arises from the importance of the

financial system in a modern economy, the recognition of the high degree of interrelatedness of the components of the financial system, and the role of central banks in supporting a well-functioning financial system, for example, through short-term lending to solvent financial institutions with temporary liquidity problems. Given the growing importance of financial markets, a deep understanding of how these markets operate, particularly in times of stress, is of fundamental importance to financial stability.

Central banks engage in certain financial market operations to implement monetary policy, to reinforce financial stability, and in some cases, to conduct other business lines. These operations could benefit from a more structured analysis of the relevant markets. For many central banks, financial market operations include managing foreign exchange (FX) reserves and FX market intervention. Thus, for example, while it is known that FX intervention generally has appeared to have had little effect, market microstructure research has yielded suggestions that could improve its effectiveness. Moreover, for central banks operating as their government's fiscal agent, there is an active interest to improve the functioning and liquidity of government securities markets. With falling levels of government debt, many central banks are contemplating the holding of alternative asset classes, which carries implications for the degree of liquidity and credit risk that they bear. These activities could benefit from the insights that market microstructure research could yield on the determinants and dynamics of market liquidity.

The market microstructure research program at the Bank of Canada has arisen, in part, in recognition of some of the contributions that this line of research could make. In addition, it has developed as a response to the rapid rate of change in financial markets as a consequence of technological innovations and regulatory reform. It is important for the Bank of Canada to have a profound grasp of the requirements for well-functioning financial markets as market structures evolve.

While the goal of this conference was to examine issues related to market structure and the dynamics of markets, the panellists highlighted the fact that at least two leitmotifs were at play throughout. As noted by John Chant, at the heart of all of the papers and discussions was the role of *information* in the market—the way in which market structure influences how information is impounded into prices, during normal and stressful times; how market design is influenced by informational issues; and the impact of technological change on information processing and the institutional evolution of the market. Many of Richard Lyons' comments focused on order-flow information. He pointed out the property rights issues associated with it and the value of these data (which drive business decisions). He asked how transparent markets should be with respect to these data and suggested significant research questions regarding the role of this information in asset-price dynamics. Dino Kos explored the theme of *liquidity*, particularly why central banks should care about it, its challenges at this time, and what, if anything, central banks could do to enhance it.

In this volume, we present the research under the two broad themes: financial market structure and asset-price dynamics. Here, we discuss the papers presented at the conference within the context of these two perspectives and draw the key lessons. We conclude with several important questions that arose out of the discussions.

1 Financial Market Structure

The structural characteristics of a market affect its efficiency, stability, and capacity to function well in the event of increased stress. Markets that are liquid, efficient, and that feature good price discovery (in short, markets that exhibit "good operating characteristics") will be relatively resilient and robust in the face of shocks. Financial stability characteristics can be enhanced through policies that promote appropriate (or, at least, not inappropriate) market structures.

One aspect of market structure that is thought to be important to liquidity is the extent to which markets are centralized. Network economics tells us that a market with the maximum number of potential counterparties will be the most liquid. Where there is potential for a large, liquid market to be broken up into smaller pieces (through competition, for instance), this is referred to as fragmentation. On the other hand, in relatively decentralized markets such as most fixed-income markets, network economics may not be the primary factor determining liquidity, and sweeping regulatory measures to limit market fragmentation may be inappropriate.

Similarly, the flow of information in markets is another structural characteristic that is thought to have important implications for liquidity. A high level of transparency is often seen as a key component in achieving fair, efficient, and liquid markets. Transparency seems to play a different role in different markets, however, and certain types of transparency in markets that are characterized by infrequent and "lumpy" order flow may actually introduce perverse, trade-limiting incentives for participants.

1.1 "Optimal" market structure

The wide variety of market structures confronts policy-makers with a significant challenge in trying to determine which structures may be optimal from a societal perspective. In particular, regulation that attempts to generalize across markets, implicitly assuming that differences in market structure can be explained as evidence of market failure in one case or the other, can be problematic.

Toni Gravelle compares and contrasts market structures and practices in multiple-dealer equity markets with those in government securities markets and demonstrates that there are subtle and important differences between the two (at first glance, quite similar) types of dealership markets. Intrinsic differences in the two types of securities, the nature of the investors, the degree of centralization, and transparency regimes are

highlighted. The author suggests that these structural differences are likely to significantly affect the activities of market-makers and therefore the amount of liquidity that they provide.

Nicolas Audet, **Toni Gravelle**, and **Jing Yang** approach the question of optimal market structure by developing a model in which customers choose to trade in either a dealership or a limit-order-book market. Their findings suggest that a dealership market will be preferred by investors in an environment where customer trading is relatively thin and "lumpy," and by investors who are subject to relatively large liquidity shocks. This is consistent with the observation that markets dominated by a relatively small number of institutional investors tend to be organized as dealership markets.

Market structures develop to meet the (often idiosyncratic) needs of market participants. This suggests that there is no one structural form that is optimal for every market or for every participant in a given market.

1.2 The impact of changes in market structure on market quality

Market structure, which describes the behaviours of participants and the trading architectures or protocols in a market, has an important effect on the quality of markets. Given the observation that different structures may be appropriate for different markets in a static setting, the following papers investigate the impact of a change in structure. The first paper studies an actual change with respect to transparency requirements, and the second examines the potential effect of consolidation.

Ananth Madhavan, **David Porter**, and **Daniel Weaver** investigate the effect on market liquidity of an increase in pre-trade transparency on the Toronto Stock Exchange that occurred in April 1990. Contrary to the assumption that higher transparency would lead to higher quality markets, the authors find evidence that market liquidity suffered as a result of the change.

Chris D'Souza and **Alexandra Lai** examine another potential source of change to market structure: consolidation among market-makers. The authors demonstrate that if the merged entity has a greater risk-bearing capacity than the original pre-merger entities (through a greater degree of diversification among its business lines), consolidation may lead to a net increase in the amount of risk capital allocated to market-making activities, improving market liquidity and investor welfare.

The potential effects on market quality of a change in market structure may be counterintuitive. Such questions require careful analysis.

1.3 Technology and the evolution of market structure

Far from being static, market structure is in a constant state of flux. For example, improvements in information technology, particularly the advent

of electronic trading, are having a dramatic impact on market structure. It is important to understand these changes and their implications for market quality.

Ian Domowitz examines the relationship between trading costs, technology, and the role of intermediaries in financial markets. He shows that the pursuit of lower trading costs has led to the introduction of new, automated trading mechanisms and venues, resulting in potential disintermediation for some intermediaries (traditional retail brokers and stock exchanges, for instance). The move towards limit-order-book markets is discussed. The paper suggests, however, that this new landscape brings with it a fresh set of challenges, such as liquidity management for participants, which create opportunities for disintermediated entities to reinvent or "reintermediate" themselves.

Allison Holland describes the phenomenon of electronic trading in the U.K. debt markets. She outlines the Debt Management Office's (DMO) policy response to the challenges raised. The DMO's decision to introduce a central, committed interdealer market, while leaving the customer market and the overall level of transparency in the gilt market essentially unchanged, was taken on the basis of an assessment of the fundamental differences between the various market segments.

Technological innovation is fundamentally changing financial markets and the roles of participants, raising potential issues regarding competition, fragmentation, and transparency. If a policy response is considered necessary, it must also address the differential impact that these forces will have on various markets and market segments.

2 Asset-Price Dynamics

Policy-makers are interested in discovering how and why financial market crises originate and propagate across markets. An understanding of how market participants interact with each other, and the incentives that they face, will illuminate these issues. In this context, market-price dynamics are seen as the aggregate effect of the multitude of path-dependent trading decisions made by individual market participants during every minute of the trading day. Seemingly inconsequential details of how markets are structured and how participants interact may, therefore, have important implications for the behaviour of market prices. High-frequency, even tick-by-tick, trading data are often necessary to test market microstructure hypotheses. With the advent of electronic trading, this level of detailed data is becoming increasingly available.

2.1 Understanding dynamics in light of market microstructure

Martin Evans and **Richard Lyons** estimate the price impact of wholesale trades in foreign exchange markets, and they find strong evidence of temporary and (economically significant) persistent price effects from portfolio rebalancing. They also find that these effects are greater when the

flow of macroeconomic news is strong. With respect to intervention in currency markets, these findings imply that intervention trades will have a significant price impact if they are sterilized, secret, and provide no policy signal, and that this intervention will have the strongest impact when markets are reacting to macroeconomic news. Within this specialized model, the paper presents a methodology for estimating the impact of such action.

2.2 Price dynamics in markets under stress

Focusing on the interdealer U.S. Treasury market during the Long-Term Capital Management crisis in the autumn of 1998, **Craig Furfine** and **Eli Remolona** examine how different price discovery is in a market under stress. They find that trade flows have an increased impact on prices during periods of heightened trading activity and when market depth is asymmetric. Their findings also suggest that trading had a greater price impact during the crisis, even after controlling for the effects of heightened activity and asymmetric depth.

Toni Gravelle, **Maral Kichian**, and **James Morley** develop a model-based technique for identifying periods of high and low variance by the study of "shift contagion," where correlations between market prices systematically increase during crisis periods. Their methodology has the added advantage that the source of a crisis need not be known. The authors find evidence of shift contagion in the currency markets of developed countries, but not in the bond markets of emerging-market economies.

Markets may behave in a significantly different way when under stress than they do during normal times. Research and policy must take account of the "state-dependent" nature of price dynamics and market behaviour.

Some Continuing Questions

While the research presented led to a number of conclusions, the discussions stimulated several important questions that point to possible directions for future research.

- Are there public-good aspects to market liquidity? If so, what are the implications?
- While markets generally evolve towards good and workable structures, can the existence of multiple equilibria impede the development of first-best solutions? How can first-best solutions be identified? Can policy-makers move markets to first-best optima? Should they?
- What drives market stress? Are there different types of stress, and if so, how are they characterized? Can and should central banks act to alleviate stress? If so, when and how?
- Where are technological developments taking financial markets? Will they make financial markets more efficient? more stable? more resilient? If so, to what degree? Are there costs? And if so, what are

they? How far will consolidation go? What are the implications?

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1. In this volume, we have chosen to present, on an experimental basis, non-technical summaries of all of the papers presented. This decision was taken to allow our presenters to publish their conference papers in refereed journals. Where possible, references to the full-text versions of the paper are found on the first page of each of the summaries. The volume also contains the remarks of the discussants, summaries of the floor discussions, and the panel discussions. Great care was taken to ensure that the volume contains all of the insights generated by the conference.

2. Here we define financial stability as a situation in which there is no meaningful risk that financial system failure would result in significant macroeconomic costs.

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Opening Remarks

Ron Parker

I would like to welcome you to the Bank, and I encourage you to participate in the discussions that will take place over the next two days. I hope that we can build some real connections across the different types of participants represented here—academics, market participants, and policy-makers, because we are confronted with rapidly changing markets and difficult policy questions that require a real blending of the expertise that you all bring to the table.

My remarks will focus on two things: first, why is the Bank of Canada, and perhaps central banks in general, interested in market microstructures; and second, what policy issues have been the focal point of our attention thus far?

At the broadest level, the Bank of Canada is interested in the microstructure of markets because they play an important role in the efficient allocation of capital. Well-functioning markets, often described as liquid markets, are one of the core features of a well-functioning economy. The efficient transfer of information through markets is an enormously important public good.

Markets are playing an increasingly significant role in the capital-allocation process in many industrialized economies. While banks and other financial intermediaries are still very important sources of funds, the proportion of funds raised through equity and debt markets has risen considerably. Indeed, it is not uncommon to hear the argument that the development of markets has led to increased financial stability—when one source of funds is not functioning well, the other channel may be available.

How well markets function is also crucial for at least three reasons, all of which touch upon efficiency in some way.

First, how well markets function can have a significant effect on the willingness of domestic and foreign investors to participate in markets, which is why the quality of regulation and codes of ethics guiding participant behaviour is so important.

Second, well-functioning markets have a direct bearing on the implementation of monetary policy, because it depends on the efficient transmission of information from the policy interest rate to other financial asset prices.

And third, the efficiency of market structures during times of stress is of considerable importance from a financial stability perspective—does the transmission of shocks across markets affect the stability of the financial system as a whole?

Consequently, central banks have an interest in how well markets function. One might ask, however, what contribution central banks can bring to the policy debates around market structures.

I think one of the unique contributions of central banks is a focus on the economic incentives underlying a particular set of market structures. Incentive structures and moral hazard are major issues for central bankers. These are things that we think about a lot. Central banks also approach issues from a broader macroeconomic or system-wide perspective rather than from a sectorial or regulatory one. Perhaps most importantly, they bring a mix of practical experience and applied research that can provide useful insights for understanding particular markets, especially fixed-income and foreign exchange markets.

I would like to move on to discuss the second question: the policy issues that have been a focal point for our microstructure research.

Several years ago, the Financial Markets Department started looking seriously at microstructure issues as part of our research program when it became clear that the number of developments affecting how markets are organized and how well they might function was accumulating. We needed to be able to better understand how some of these shocks might affect markets in Canada.

The following shocks seemed relevant.

- First, changes in technology are having very large effects on markets, but perhaps one of the most significant consequences of the rapid decline in computing and telecommunications costs is its effect on how markets are organized: being part of the network through which information is flowing or part of the network delivering a particular set of services to clients is becoming much more important. But whether these changes in

technology have affected the monetary policy transmission mechanism and where markets will be located are of particular interest to us.

- The introduction of the euro and the harmonization of the legal and regulatory framework in Europe.
- Changes in the regulatory environment, such as new and evolving capital standards and new ways of managing financial risks.
- Consolidation across both financial intermediaries and investors is another trend we are observing. While this is almost certainly not independent of other changes such as the economies of scale technology now makes possible or more efficient risk-pooling (also brought about by technology), from a policy perspective, it gives rise to a number of competition and market-structure issues.

One focus of our work has been on the market-structure implications of electronic trading systems in debt markets. This research is reflected in a number of the Bank papers prepared for this conference. Two themes have emerged from this work.

First, common transparency standards across all types of debt markets could be counterproductive, especially in wholesale debt markets. There are, for example, important differences between order-driven and quote-driven market structures. The appropriate level of transparency can also be a function of the stage of development of markets—how easily information is absorbed and risk is transferred, for instance. Transparency rules should also consider differences in trade types: retail-type trades, non-market-moving trades, and non-information-carrying trades are very different from wholesale-market trades that may have considerable information content.

The second theme has been that increased transparency in markets may not necessarily result in more optimal outcomes. In government or other bond markets, greater transparency may harm liquidity, since it could affect the ability of dealers to manage their inventory risk and therefore result in less efficient overall allocation of risks in the market.

These observations have led us to the conclusion that from a policy perspective, one should avoid a "one size fits all" approach when assessing the need for market rules.

Our work has underscored the fact that market microstructure changes give rise to numerous trade-offs with gainers and losers, so it is not possible to describe "optimal" trading arrangements, as observed by Helen Allen of the Bank of England and her BIS co-authors (Bank for International Settlements 2001). These challenges seem even larger in a marketplace like Canada's that is dominated by a relatively small number of large dealers and a

relatively small number of large investors. Determining what changes will do no harm, as Mr. Greenspan advises, is what our research program is about and I know that this conference and the discussions over the next two days will make an important contribution to the policy decisions that lie ahead.

Reference

Bank for International Settlements. 2001. "The Changing Shape of Fixed Income Markets." Working Paper No. 104. Study Group on Fixed Income Markets.

Session 1:
Financial Market Structure

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The Microstructure of Multiple-Dealer Equity and Government Securities Markets: How They Differ*

Toni Gravelle

Until recently, much of the research concerned with the microstructure of securities markets had focused on equity markets. It should therefore come as no surprise that market microstructure research has been heavily weighted towards the development of *asymmetric information models*, in which a subset of market participants have private information about the expected value of an asset. The preponderance of asymmetric information models results from the bias in market microstructure research towards the price-discovery process in equity markets. That a stock's fundamental value will likely depend on factors that are idiosyncratic to the firm, and that changes in these factors are not disseminated to the public on a continual basis, guarantees a dominant role for asymmetric information in the trading process.

Across developed economies, one observes two predominant types of equity markets: order-driven, auction-agency markets and dealership markets. Order-driven markets or order-book markets, such as the Paris Bourse, are structured as (two-sided) auctions in which there is no intermediary. Incoming orders submitted to the market are either "matched up" with offsetting standing orders previously submitted to the market and placed in an electronic order book, or they are placed in the book until an offsetting order is submitted. Although a considerable amount of research has examined

* The complete version of this paper has been published as Bank of Canada Working Paper No. 2002–9. The electronic version can be found on the Bank of Canada Web site.

both types of equity market structures, much of the equity *dealership* models have focused on a particular equity market, the New York Stock Exchange (NYSE).[1] Because the NYSE is a specialist (single-dealer) market, most of the dealership models in the market microstructure literature assume a single-dealer equity market rather than a competitive *multiple*-dealer market such as Nasdaq in the United States and the London Stock Exchange (LSE). Unlike single-dealer markets such as the NYSE, market-makers in multiple-dealer markets must compete directly for their share of the order flow.[2] Moreover, competing dealers have the option of laying off unwanted inventory positions by trading with other dealers. In this way, they are able to share their inventory risks across the market-maker community, rather than being forced to rebalance their inventories by waiting for the arrival of public investor orders, as is usually the case for the NYSE specialist.

The dearth of microstructure research on multiple-dealer markets has been reversed recently with the work of Lyons (1995, 1996, 2001); Saporta (1997); Vogler (1997); Hansch, Naik, and Viswanathan (1998); Reiss and Werner (1998); and Viswanathan and Wang (2000, 2002). An interesting result of this recent work is that the inventory management behaviour of dealers plays an important role in these markets, both in terms of the price-discovery process and in the provision of market liquidity. And this result revives a second strand of microstructure research known as *inventory models*, where dealers adjust their quote and trading behaviour to restore inventories to a desired level. The innovations brought forward by this line of research assume that dealers are risk-averse and that they trade in a strategic manner to extract information from other dealers.

What is striking in the field of market microstructure research is how little work has been done on the microstructure of bond markets. This lack has persisted in spite of the size and importance of sovereign government securities (GS) markets, which are usually the largest segment of a developed country's fixed-income or bond market. Fortunately, GS markets in most developed countries are structured as multiple-dealer markets, and they function in many ways like multiple-dealer equity markets, which recent research has examined. However, there remain several important differences between GS and equity dealership markets that may make

1. The NYSE is, in fact, a hybrid market combining order-driven and (single) dealership structures into one trading system.

2. Specialists on the NYSE also face competition of a similar nature. They must compete with the order book, which lists all standing limit orders. However, the competition is, to some extent, on the specialist's terms. That is, since the specialist observes all the order flow for the stock (including that flowing to the order book), the specialist can set the bid and ask price based on this knowledge.

results garnered from the recent research inapplicable to GS markets. One purpose of this paper is to examine the differences between equity dealership markets and GS markets in order to better understand the factors affecting the liquidity and efficiency of GS markets. As discussed in Gravelle (1999) and Bank for International Settlements (2001), well-functioning GS markets play a key role in the maintenance of a stable financial system.

The paper begins by examining the differences between intrinsic features of equity and GS securities, such as the predominance of public versus private information, maturity characteristics, and hedgeability. Although it is natural to assume an asymmetric information trading environment for equity markets, this cannot be assumed with GS markets. Prices for GS form the term structure of the underlying risk-free interest rates. These rates, in turn, depend on macroeconomic factors about which investors will not have private information. In GS markets, private information about the asset's (expected "fundamental") value, what Cao and Lyons (1999) define as payoff-relevant private information, is likely to play a relatively minor role in the trading behaviour of agents. Thus, one of the differences between equity and GS is the amount of payoff-relevant private (or insider) information that is embodied in each type of security. One can safely assume for modelling purposes that GS traders hold zero payoff-relevant private information, while equity securities traders hold some positive private information. This implies that traditional market microstructure asymmetric information models based on the prevalence of investors who are better informed than dealers, are likely ill-suited to describe the trading environment of the GS market.

Term to maturity also affects the trading decisions of market participants and, in turn, the relative market liquidity characteristics. Stocks have an infinite maturity, while government debt securities have a finite term to maturity. A finite maturity structure implies that investors have the option of waiting to liquidate their position at the security's *known* maturity date, in addition to liquidating their position before that date through the secondary market. A government debt security provides the investor with the option of fixing the holding period to a known date. This therefore generates two types of GS investors: buy-and-hold and trading market participants. The existence of buy-and-hold investors for GS implies that the supply of the GS available for trading—*the floating or effective supply*—is less than the total

(outstanding) supply, which is not the case for equities.[3] It is argued that as the GS becomes more seasoned, the effective supply of the security declines, which in turn has a negative impact on market liquidity.

One of the important properties of GS inventories relative to equity inventories is that there are many more instruments available to hedge GS inventories. Market-makers can borrow or lend the same security in the repo or lending markets, they can hold the opposite position of a nearly identical bond (one with a similar duration), or they can offset this position with one in the related futures contract. For equity market-makers, avenues for hedging inventory balances in a specific stock are, for all but the most actively traded securities, much more limited. Often, the only inventory risk adjustment available to equity market-makers is to rebalance inventory. The greater ease of inventory price hedging for the GS market-makers relative to their counterparts in equity markets makes GS market-makers able to endure greater extremes in their inventory balances relative to equity market-makers. This would have to be taken into account when modelling the inventory management behaviour of equity market-makers relative to their GS counterparts.

Section 3 of the paper shows that subtle structural differences exist between GS and equity dealership markets. Dealership equity markets (such as the LSE and Nasdaq) are centralized, while multiple-dealership GS markets are decentralized. Decentralized and centralized markets are distinguished by the amount of information that is available to the public (to customers and dealers alike) on a consolidated basis. Here, "consolidated basis" means that price and trade data from the spectrum of dispersed dealers are available on a single screen. For example, multiple-dealer quotes on Nasdaq are generally available to the public in a consolidated format such as a single Bloomberg page. In contrast to multiple-dealer equity markets, investors in GS markets cannot easily ascertain what is the best, most current bid-ask spread being offered by the dealers. In principle, the only way for an investor to ascertain which dealer has the best quote in a decentralized market would be to contact each dealer directly. However, in the U.S. and European GS markets, electronic trading systems such as TradeWeb and BondVision have increased the degree of centralization in these markets, since they allow investors to view multiple quotes from multiple dealers on

3. Note that some firms may choose to hold (or repurchase) a proportion of their own stock, thus allowing the amount of the stock available for trading to differ from the total amount of issued stock. However, since the firm's objective in holding some of its stock is to maximize its price, the firm avoids reducing the supply of the stock to the point of affecting liquidity. Furthermore, it should be clear that a floating supply of GS arises from the utility-maximizing behaviour of the investors and not the issuer.

one screen, i.e., in a consolidated format.[4] These electronic trading platforms allow investors to solicit quotes from a number of participating dealers simultaneously, without having to contact them sequentially over the telephone (as is traditionally the case), and then trade electronically with the dealer of their choice.[5]

In section 4, we examine differences in the transparency of equity and GS dealership markets.[6] The degree of transparency in equity dealership markets such as Nasdaq and the LSE tends to be greater than that observed in GS markets. This stems in part from the centralized nature of the equity dealership markets, where dealer quotes are reported on a consolidated basis. Given the decentralized nature of most GS markets, consolidated pre-trade quote information is generally not available to public market participants. Therefore, key factors underlying the degree of transparency in dealership markets are the existence of a system that consolidates and collects (links electronically) the individual dealer quotes, and the accessibility of these data by potential market participants. However, since a feature of these systems is their ability to transmit (electronically to information providers) the indicative quotes posted by dealers participating in the system, the recent arrival of electronic multiple-dealer systems in the public (customer-to-dealer) sphere of GS markets has increased the degree of consolidation and, in turn, the degree of pre-trade transparency in U.S. and European GS markets.

The potential effect of greater transparency on dealership markets and how the regulatory approach to mandating transparency should differ across equity and GS markets are also examined in section 4 of the paper. There is a well-known tension between post-trade transparency and market liquidity and trading costs. Greater disclosure of post-trade information in the public

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4. These systems operate in the public sphere of GS markets and should not be confused with electronic fixed-income interdealer broker (IDB) systems such as EuroMTS or eSpeed, which cater to interdealer trading.

5. Although these electronic systems offer a significant improvement in time savings and operational efficiency (particularly the back-office efficiencies offered by straight-through processing), these quote-driven systems do not alter the way investors interact with dealers. These systems represent simply an automation of the telephone-based investor-to-dealer interaction. Moreover, GS investors (and dealers) participating in these electronic trading platforms remain concerned with minimizing the price impact (or trading) costs of large GS transactions.

6. A market is generally more transparent when more data on the market's internal trading processes are publicly available. In dealership markets, a market is classified as being pre-trade transparent when traders (customers and dealers) can directly view all or, at a minimum, the best firm bid-ask quotes offered by the spectrum of market-makers. Post-trade transparent markets, on the other hand, are defined as those that report all completed trades to the public immediately.

sphere of dealership markets may not benefit the overall market, since it affects a market-maker's ability to carry out inventory risk-sharing activity. These market-maker incentives help explain the different approach to post-trade equity market transparency taken across jurisdictions. This helps to explain arguments defending delayed trade reporting for large orders on the LSE, as discussed in O'Hara (1995, 258–9) and Board and Sutcliffe (1995).

The optimal level of post-trade transparency is likely to vary, considering the differing sensitivities of market-makers to revelation risks in these markets. Market-makers handling large orders tend to be particularly sensitive to so-called "Hirshleifer revelation risks" (Lyons 1996 and Naik, Neuberger, and Viswanathan 1999). Because revelation risks have made it increasingly more costly for market-makers to manage their inventory, these additional costs must be passed on to investors. The larger the trade and/or the less frequent the trading activity, the more susceptible market-makers are to revelation risks. In the end, investors who must transact relatively large-size orders are worse off, because they must trade in a market that charges a higher price (in terms of bid-ask spread, for example) to access the market liquidity services provided by market-makers. Since public investors in GS markets are predominantly large institutional investors, whereas there is a preponderance of small retail investors in equity markets, it is likely that less post-trade transparency in the public sphere of GS markets than is currently observed in equity dealership markets would be appropriate.

Section 5 of the paper examines the factors underlying the relationship between the scale of interdealer trading and market-maker inventory risk management practices, and it highlights gaps in the literature in this area. Data provided show that dealers in markets such as the GS markets tend to rely almost exclusively on IDBs when trading among themselves, while dealers in the FX markets tend to trade bilaterally. In addition, the data indicate proportionally more IDB trading in GS markets than in equity dealership markets. Differences in the arrival rate of customer orders and the variation in size and direction of these orders across markets may help to explain these stylized facts.

Risk-averse dealers, subject to greater order-arrival variability and/or order-size variability, will probably require more inventory risk management services. Interdealer trading will occur as dealers choose between the uncertainty of public order arrival and the certainty of interdealer trading. Dealers are also more likely to require the anonymous trading offered by IDBs (rather than "name-give-up" direct interdealer trading) if the order's size is large enough to move markets. Thus, the fact that GS market-makers receive orders that are, relative to their desired (risk-adjusted) inventory

level, larger as well as less frequent than their counterparts in dealership equity markets, results in the greater use of IDBs in GS securities markets.

On the other hand, GS market-makers are better equipped to manage inventory risks and seem less sensitive to inventory variations. Evidence indicating that the size of U.K. GS market-maker inventory imbalances does not influence the quote prices suggests that the market-makers do not aggressively manage their inventory levels. Relative to equity market-makers, GS market-makers have access to several hedging avenues (futures or repo contracts, for example), and this suggests that they can manage their inventories less aggressively. Consequently, GS market-makers can endure a greater divergence from desired inventory levels and, given the lower inventory rebalancing needs, are less likely to engage in interdealer trading. This contradicts the data indicating that GS market-makers rely heavily on IDB trading relative to equity markets.

This contradiction may be explained by the fact that for GS market-makers to competitively supply liquidity to the public sphere, they must be able to endure greater inventory imbalances *and* engage in interdealer trading. More precisely, even though GS market-makers require larger inventory imbalances before engaging in interdealer trading, they are nonetheless relatively active participants in the interdealer sphere, because GS order-flow dynamics bring about frequent and extreme inventory imbalances. Moreover, interdealer trading is motivated by information extraction. That is, dealers either endeavour to ascertain market-wide order-flow information by observing the order flow passing through all IDB systems,[7] or, by trading in the interdealer market, they are able to garner a sense of the depth of the market at a given price.

The paper's discussion can be summarized as follows. Although multi-dealer government and equity securities markets have, on the surface, similar market structures, the paper demonstrates that there are differences between these markets that are likely to significantly affect the way market-makers trade and, as such, have an impact on the liquidity that market-makers provide. Moreover, policy-makers should be wary of applying similar regulations across both equity and GS markets, since these rules may, in fact, be detrimental to the investors that these rules seek to benefit.

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7. Lyons (1996) suggests that IDBs play a role in the information extraction process for FX dealers. GS markets are very similar in terms of information flows and order-arrival dynamics to FX markets.

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Discussion

Jos R. Heuvelman

My comments will not be of a scientific nature, but should be viewed as a number of observations that I hope will provide some guidance for researchers in the area of the microstructure of financial markets.

Toni's paper examines the differences between the microstructure of equity and fixed-income markets. A lot of research has been conducted and published on the equity markets, both dealership and auction-type markets, but much less on the fixed-income markets—which is not surprising, given the limited availability of data. Fixed-income markets are dealership markets, and thus might be similar to certain equity markets, Nasdaq, for instance.

This raises the question of whether or not the models and results of equity-market research are applicable to fixed-income markets. The paper attempts to answer this question by looking at the differences between the two markets.

Gravelle argues that an important difference is the existence of inside information in the equity markets, and the absence of it in fixed-income markets. I agree with the latter: there is hardly any private information in the fixed-income markets, apart from some flow information that dealers reap from their activities in secondary trading. But I am surprised to learn that there is a dominant role for inside information in the trading process for equities. There are, of course, different views among the various parties, but I find it difficult to accept that non-public information is the dominant motive for trading, particularly given the relative importance of retail investors in the stock markets.

The different nature of the product is also discussed in the paper. Since, unlike equities, bonds have a finite maturity, they attract a certain category of investors—those who buy and hold assets until they mature. This means

that the effective supply, available for trading in the secondary market, diminishes, making it more difficult for market-makers to run a book. I think it is worthwhile to point out—be it for different reasons (mainly strategic investments)—that a similar situation prevails in the equity markets. Just this week, in fact, Morgan Stanley Capital International introduced a fundamental change to its indexes to reflect the fact that the free float of stocks can differ significantly from the amount originally issued. In some countries, the free float is less than 50 per cent, whereas the average is 85 per cent!

Perhaps a more fundamental difference in the nature of equities and bonds is that the risk profile of a bond is not constant over time. A ten-year bond, for example, will be a nine-year bond in one year's time. On the other hand, a particular stock is the same now and in one year from now, i.e., its risk characteristics don't change. And since market-makers manage exposures rather than individual securities, this has a bearing on how market-makers in the fixed-income and equity markets manage their inventories.

Another aspect where the two markets differ is the decentralized nature of the bond markets versus the centralized equity markets. Decentralized trading could lead to different prices for the same bond at the same moment, which is unlikely for equities, given the centralized price information. However, this difference should not be exaggerated, for several reasons. Investors in bond markets tend to be sophisticated players, with more than one price source available—increasingly so, with the advent of multi-dealer electronic platforms such as TradeWeb. Furthermore, correlations within the bond markets are much higher than in the stock markets. Government bond futures are traded on exchanges, which are fully centralized trading places. Every market participant knows exactly what the futures price is at any moment. Given the high correlations in bond markets, sophisticated investors would have a pretty good idea where the price of ten-year bonds, for example, should be.

The final issue that I will discuss is transparency. The paper argues that, with the different natures of the two markets under review, a different level of transparency is needed. In general, one can say that whenever there is a change in transparency, some market participants win and others will lose. Thus, there is plenty of scope for vested interests to try to prevent such changes. The current level of transparency in the stock markets is mainly the result of regulation. In most bond markets, on the other hand, there is not much regulation, as far as I know. And the dealer community itself is not likely to be a driving force for more transparency. The biggest stimulus to transparency has come from Michael Bloomberg and his associates. Consequently, an important distinction between bond and stock markets is

the level of regulation. When assessing transparency in both markets, this factor should not be overlooked.

I agree with the paper's conclusion that there are many differences between bond and equity markets, even those that are organized as multi-dealerships. One should therefore be careful about using the results of equity-market research to draw conclusions regarding bond markets. But I will add one observation: bond markets are becoming more centralized. We are currently in a hybrid situation. It would be interesting to hear some views on where this is going and what factors will determine the outcome. Perhaps we can learn something from the equity markets.

Finally, the paper assumes that there is a role for regulators in the fixed-income markets. But is there really a need for regulators to step in, or should we leave it to the competitive forces to create an optimal trading environment in the fixed-income markets?

General Discussion*

Richard Lyons noted that in the foreign exchange (FX) markets, the share of interdealer trading done through interdealer brokers (IDBs) is about 50 per cent. That was true through the 1990s when most of the empirical work was done in FX markets. Recent BIS reports suggest that, as of the end of last year, the IDB share of interdealer trading in FX is up to about 90 per cent. So, over the last few years, there has been a very rapid move in that market towards IDBs and away from direct interdealer trading, and the market has become more concentrated. Lyons suggested that there are fewer dealers, which goes in the opposite direction of the Saporta (1997) results that the author had mentioned. Lyons asked Toni Gravelle whether he thought that this time series might help shed light on the issues that were the focus of the paper and whether the non-squaring with Saporta's results made sense to him.

Gravelle responded that the time series is similar to a controlled experiment, where there is trading in the same security. It would therefore be interesting to see what has changed over time. He suspected that electronic IDBs have come to these markets and have reduced the cost of trading via IDBs, which might explain some of the change in proportion of IDB trading in fixed-income markets. As for squaring with Saporta's results, Gravelle said he would have to think about that.

Jos Heuvelman mentioned that he had recently conducted a small survey where he had asked seven large dealers in the U.S. treasury market and seven large dealers in the European government bond markets how much of

* Prepared by Serge Boisvert.

their interdealer trading was done through the IDBs and how much was done direct. Each one of them responded that it was all done through IDBs.

Asani Sarkar asked how the differences in equity and government bond markets would be manifested in the data. He suggested that research in these areas had shown that there were a lot of similarities in the empirical relationships. If one looked at the time-series properties of liquidity in government bond and equity markets, one would find that they were quite similar. For example, there are very similar day-of-the-week effects, a similar autocorrelation structure in bid-ask spreads, and similar kinds of relationships between returns and spreads. He asked the author if he had any thoughts on that.

Gravelle replied that one of the things they had examined was the customer order flow. If there were two dealers, one in equity markets and one in government securities markets, one would notice huge differences in order flow. Many equity-market dealers have preferencing arrangements, so they have a continuous order flow and are vertically integrated. They have a broker underneath them, so their order flows are relatively constant or homogeneous, whereas the order flows of government securities dealers are quite different (very infrequent, but large size). When there is a macro-economic news release, order flow is very one-sided, either all buy or sell. Gravelle said one would really want to look at the dealer blotter to get a sense of the changes in order flow that might explain the differences in bid-ask spreads, the depth, and the robustness of these markets.

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Saporta, V. 1997. "Which Inter-Dealer Market Prevails? An Analysis of Inter-Dealer Trading in Opaque Markets." Bank of England Working Paper No. 59.

Optimal Market Structure: Does One Shoe Fit All?*

Nicolas Audet, Toni Gravelle, and Jing Yang

There is a growing realization among regulators and managers of competing trading venues (incumbent stock exchanges, in particular) that the design of the trading mechanism is the most important determinant of a market's ability to compete for order flow. To understand how different trading venues succeed in capturing trading activity in a particular security, one has to understand which attributes of the trading venue are most important for trading activity. Moreover, the ability of different trading mechanisms to offer lower trading costs to an investor depends critically on the trading needs or characteristics of the investors themselves. Given that investors seek best execution of their trades, and best execution encompasses traded price, market impact, immediacy, timing, anonymity, and commissions, it is not surprising to see investors choose different trading venues based on how well each venue fulfills different combinations of these aspects' execution quality.

Our paper seeks to answer the following question: If customers could choose the market structure to trade in ex ante, which market structure would they choose? That is, what determines a market participant's choice of trading in an order-book market versus trading in a dealership market? We also seek to analyze how the trading environment and customer trading characteristics affect the choice of trading mechanism.

* The complete version of this paper will be published as a Bank of Canada working paper under the title "Alternative Trading Systems: Does One Shoe Fit All?" The electronic version will be available on the Bank of Canada Web site.

Despite the fact that new trading systems have come along and attracted significant trading activity, little theoretical or empirical work has examined the considerations that determine a participant's choice of market mechanism. That investors are observed to send their orders to different trading systems (Conrad, Johnson, and Wahal 2001) has been the focus of little research. Most research has concentrated on modelling one trading mechanism and often simply examines mechanism efficiency in terms of price discovery. O'Hara (1995) provides a survey on continuous order-book and dealership models. Since each study surveyed used different modelling techniques, however, it is difficult to compare their results.

While it is desirable to examine which market structure best serves individual investor needs in terms of execution quality, it is generally very difficult to study both dealership and limit-order-book structures in a unified analytical framework using standard market microstructure modelling techniques. Empirical research that carries out intermarket comparison is very difficult as well, because actual market structures are more complicated than the models on which empirical tests are based. Furthermore, existing empirical research has carried out intermarket comparison based largely on a measure of the bid-ask spread, which is only one dimension of execution quality. These studies fail in general to examine other measures of execution quality that could help explain why various market structures coexist. Empirical research is also impeded by a lack of detailed data surrounding events where the market structure has undergone a regime change. Such data would allow researchers to more directly test theoretical hypotheses; see Madhavan (2000) for more on this.

To examine the optimal market structure preferred by market participants, this study constructs an agent-based computational model of both a dealership and limit-order market. (See LeBaron 1999, 2001, and 2002 for a review of agent-based modelling.) This methodology starts where theoretical market microstructure models leave off, in that it allows researchers to examine questions that are analytically intractable in a purely theoretical construct. In our study, the agent-based simulation methodology is structurally grounded by an analytical model that guides the behaviour of the artificial or simulated traders. One of our goals is to illustrate the applicability of the artificial financial markets approach in the study of market design issues.[1]

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1. This methodology should not be confused with the experimental markets studies that use human participants in a laboratory setting, such as Bloomfield and O'Hara (1999, 2000), Flood et al (1999), and Theissen (2000). Although studies such as these allow researchers to examine the effects of changes in market structure on measures of execution quality, as is the case in our agent-based artificial market framework, this type of research also has the disadvantage of being sensitive to how the experiments are set up, how the human participants are chosen, or how they learn to play the experimental game.

The analytical framework on which the agent-based simulation is constructed is based on a market microstructure modelling approach. First, an institutional feature of many equity markets, such as the TSE and the Paris Bourse, is that trading is organized as a continuous limit-order-book system. We model the limit-order-book market as a double auction, where market participants submit bid and ask orders to the system. The trading system then clears the market and determines the price. Each risk-averse market participant is rational and seeks to maximize expected utility from trading. As such, market participants realize, to the extent that they are the marginal buyer or seller in the system, the impact that their orders have on price, and they act strategically.

Second, we model the dealership trading architecture as a two-stage trading process. This captures a key institutional feature of dealership markets such as foreign exchange and fixed-income markets. In the first stage, dealers trade with rational, liquidity-motivated public investors. These dealers post bid and ask prices and are committed to trade for any quantity at these prices. After observing their liquidity shock, each public investor chooses the size of order to submit against a dealer's quotes. The risk-averse dealers subsequently retrade in the interdealer market via interdealer-broker systems to lay off the inventory risk they obtained in the first stage of trading.

In the first stage of trading, dealers compete for customer order flow on price, à la Bertrand competition, while second-stage interdealer trading is modelled as a limit-order trading mechanism. Therefore, the interdealer trading system is specified in an identical manner to the stand-alone limit-order market structure described above. Only dealers trade in this market, however, and they are motivated by their desire to lay off their unwanted inventory positions. Dealers realize the impact that their orders have on their share of the total surplus among dealers and act strategically to maximize it. This two-stage trading process implies that the dealership market is actually a combination of two market structures. In turn, the dealer's quotation strategy in the first stage, when facing public investors, is a function of the trading environment that the dealers face in the second stage of trading.

We compare the welfare of rational public investors who trade in a dealership market with those who trade in a limit-order market. Although policy-makers and market designers are generally interested in the standards of execution quality that different market structures provide, we assume that the multi-dimensional nature of execution quality can, in the end, be summarized by its impact on investor welfare. We consider a framework where utility-maximizing public investors (customers) supply orders to the market based on the liquidity shock they receive just prior to entering the market. In essence, customer trading is motivated by the desire to share

liquidity risk among a greater set of participants. Given that customers are identical except for their realization of the liquidity shock, the degree of customer heterogeneity is defined over their liquidity shocks. Adjusting the distribution from which the liquidity shocks are drawn allows us to vary customer characteristics related to order size. Customers are also characterized by the correlation of their trading needs. When this correlation is high, customer orders tend to be on one side of the market.

By varying customer characteristics, we examine a range of market-structure issues. As noted in Viswanathan and Wang (2002) and Gravelle (2002), markets that primarily involve institutional traders who tend to generate large order flow, such as fixed-income and foreign exchange markets, are organized as dealership markets. On the other hand, markets that handle primarily small orders generated mainly by retail stock-trading investors, such as the downstairs segments of NYSE, the TSE, and the Paris Bourse, are structured as limit-order-book markets. Our study investigates how the optimal market structure for customers whose order size is sometimes large and varies considerably may differ from that for customers characterized by relatively small, homogeneous order flow.

Another concern of this study is to examine customer choice of market architecture under different trading environments. The trading environment is defined over the thickness of the market, the number of market-makers, the degree of market-maker heterogeneity, and the risk-aversion differential between market-makers and customers. Different market structures could be better suited to overcome various coordination or trading frictions in financial markets. For example, a feature of fixed-income and, to a somewhat lesser extent, foreign exchange markets, that differs markedly from equity markets, is their thickness: the number of buyers and sellers trading in the market at any one time.[2] As such, the observation that these markets are relatively thin might explain why the public trading segment of fixed-income and foreign exchange markets is structured as dealership systems.

Our findings suggest that the trading environment has an important impact on the optimal market structure. The public investor's choice to trade in a particular market will depend on thickness of the market measured in terms of the number of customers active in the market within a short time span. The dealership market structure is preferred by customers when there are few customers potentially available to trade. As the number of potential public investors increases, there comes a point where the number of

2. The fixed-income market is largely a wholesale market consisting of a relatively small number of large institutional investors. On the other hand, equity markets consist of thousands of traders, a large proportion of which are small retail investors.

investors exceeds a critical threshold, so that these investors prefer to trade in the order-book market structure.

We find that as the number of dealers decreases or as the risk appetite of the dealers decreases relative to that of the customers, the risk-bearing capacity of the dealership market decreases, making this market structure less attractive to liquidity-motivated public traders. As a result, the critical number of customers necessary for the limit-order-book market to prevail decreases. Increasing dealer heterogeneity is found to increase the likelihood of the dealership system prevailing.

Customers who are subject to larger and more volatile liquidity shocks will prefer to trade in a dealership system. Specifically, customers characterized as generators of large-sized order flow—which is a trait of institutional investors—are more likely to submit their orders to dealership systems than are small-sized, homogeneous order-flow suppliers. This is consistent with the observed regularity in capital markets, where markets dominated by a small number of large institutional investors tend to be organized as dealership markets.

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Discussion

Blake LeBaron

In securities markets, we observe a wide range of trading institutions. Have these markets evolved to handle specific types of buyers and sellers, or does the observed variety in markets reflect other institutional constraints or accidents of history? To address this question, we need to know something about the optimality of market institutions themselves, and who prefers particular market characteristics. It would be appealing if one optimal market structure existed for most trading situations, but as this paper reminds us, this is often not the case. Furthermore, the paper describes the conditions under which different market institutions should appear.

Trading situations currently exist between two extremes. One case involves highly transparent markets with generally open order books. Orders are fully revealed, and traders operate with full information on market location and depth. Many implications of increasing electronic trading appear to be moving towards this type of system. At the other extreme are dealer markets where trades are handled primarily through intermediaries. Here, information about order flow tends to remain hidden from the market. Traders can observe only the current set of spreads from the set of broker dealers. They do not receive information on the other orders in the system.

It may initially appear that more information, and therefore the order-book market, would be preferred, but as the authors demonstrate, this is not always the case. They model these two contrasting markets using a limit-order double-auction framework and a broker-dealer setup. Both markets are placed in a similar multi-round trading environment where agents receive an individual inventory shock that they bring to the market. Comparisons can then be made between the two types of market.

In many other studies, expediency and analytic tractability have forced the authors to use a small number of agent trading strategies. In this case, there might be one agent strategy and one dealer. The Audet, Gravelle, and Yang paper breaks from tradition by using a computational agent-based approach. These types of models analyze the overall economic dynamics from the bottom up, starting with strategies for the individuals and then analyzing the macroeconomic outcomes through computer simulations of the strategies dropped into the market institutions. The authors use a nonlinear functional form—an artificial neural network—to describe the agents' strategies. This flexible form should be able to capture many possible strategies that the players might try to implement.

What form these strategies should take, however, is an important and difficult question. The nonlinear functions have many parameters to be determined. The authors do this by using a very impressive algorithm for finding a Nash equilibrium in the nonlinear trading strategies. Technologically, this algorithm is an interesting piece of work. Once the strategies are determined, the agents can be sent into the various markets, where prices and performance are determined.

The markets are compared by changing the number of outside traders entering the market. For each number of traders, the authors ask which market would be preferred in terms of agent welfare. As the number of traders increases, the limit-order-book market is generally preferred, and as the number of traders falls, dealer markets are preferred.

The break-even point, at which traders are indifferent, is recorded and is used as an indicator for how likely it is that a dealer market would occur. If this break-even number is low, then dealer structures are probably unlikely, and if it is high, then it is much more probable that the dealer structure will occur.

Much of the paper examines the impact on this break-even number for differing parameter values. The authors find that markets with large correlated order flows tend to use a dealer-based system. Reducing the number of dealers will tend to move markets in the direction of order-book markets. Finally, reducing the risk aversion of dealers will increase the likelihood of a dealer-based market. Certainly, the first of these conclusions seems to connect with some real-world behaviour. One example might be the upstairs block trading markets on the New York Stock Exchange. The other results seem to make sense as well.

I think this framework is extremely useful, and I have some ideas for extensions. It would be helpful to know more about how nonlinear the strategies are. In the end, do traders generally stay with fairly simple linear

structures for their strategies? The experiments are run with fixed numbers of dealers. Clearly, the dealer numbers matter. Would it be possible to model potential entry and exit of dealers, making the dealer numbers endogenous? These simulations handle only liquidity shocks. Market institutions must also be good at handling general information shocks when the value of the asset has changed. This is a thorny issue, but it will eventually need to be tackled.

The performance of these markets is evaluated in terms of utility. Obviously, this is not a commonly used measure of market quality in the real world. However, these simulated markets generate values on spreads and depth, which can then be compared with real-world estimates. It would be interesting to see how closely the utility measures line up with other measures of market quality.

Finally, in terms of agent-based modelling strategies, it is important to note that the Nash equilibrium framework used here differs from many agent-based approaches. In many agent simulations, the market dynamics are analyzed out of equilibrium. It is often the actual convergence or lack of convergence that is the key issue under study. This could be done in these markets as well. However, in games where agents participate frequently, there is a case to be made for initially examining only Nash equilibria.

Market microstructure may be one of the critical areas for the use of agent-based technologies in finance. Breaking out of traditional moulds of homogeneous (or limited heterogeneous) agent worlds into a rich set of behaviours that better mimics the real world is crucial to obtaining a good picture of the properties of these market institutions. The computer also allows exploration of market conditions and settings that are not limited by analytic tractability, and are therefore closer to reality. The policy questions on market structure are pressing and important. One hopes that studies such as this will begin to give policy-makers new tools for designing markets that are both efficient and robust to a changing world.

General Discussion*

Asani Sarkar mentioned that the philosophy behind the paper is that order-driven and quote-driven (or dealership) markets are competitive with one another, while in Europe, for example, they act co-operatively. He indicated that there potentially exist positive externalities associated with the co-existence of these markets. He asked whether it would be possible to incorporate this into the paper's methodological approach.

Nicolas Audet replied that it was something they had considered and that it could be implemented. The current study does indeed assume that these markets are competitive, but their methodology could be altered so that the market in which individual agents trade could be selected endogenously.

Des Mc Manus wondered how robust their results were to assumptions such as the utility-function specification (exponential) and the nature of the inventory shocks (standard normal).

Audet indicated that while the reported results certainly depend on the assumptions, they had tried numerous configurations for the model and had attained very similar results. The model is, therefore, quite robust in this respect. In an analytical setting, one's results can vary quite dramatically and the problem can become insoluble with a subtle shift in the initial assumptions. Their model, however, can be changed by modifying a few lines of code and only the speed of model convergence is affected.

Derek Polcyn mentioned that there is resistance to alternative trading systems in the New York Stock Exchange (NYSE), since it is claimed that

* Prepared by David Bolder.

they reduce depth. He asked whether a critical mass of participants might alter the results.

Toni Gravelle responded that the NYSE is an order-driven market and thus the dealers claim that fragmentation of the market will reduce overall customer welfare; that is, it is preferable to keep all the liquidity in one spot. Moreover, these results are borne out in the paper's analysis.

Richard Lyons highlighted the fact that, using the results of their study, one might conclude that the reduction of dealers in a dealership market would imply a subsequent decrease in investor welfare. The paper nevertheless ignores the fact that a decrease in the number of dealers could actually engender a change in the aggregate risk aversion of the remaining dealers and consequently lead to higher investor welfare.

Gravelle mentioned that they do discuss this point, albeit briefly, in the paper, with ambiguous results, but he indicated that the study was primarily focused on a comparative statics-style analysis. He nevertheless agreed that a simultaneous decrease in the number of dealers could be accompanied with decreased risk aversion and, hence, increased customer welfare.

Walter Engert concluded the discussion by pointing out that this issue would be addressed in a later paper by Alexandra Lai and Chris D'Souza.

The Development of Alternative Trading Systems in the U.K. Gilts Market: Lessons and Implications*

Allison Holland

Introduction

The use of electronic trading mechanisms has become increasingly widespread in equities markets. They have also become a significant feature of some government bond markets, in particular the U.S. Treasury market, but as yet are not a significant feature of the market for U.K. government bonds, the gilts market.[1]

This paper considers the policy issues that arise from the possible introduction of such systems into the gilts market and outlines the U.K. Debt Management Office's (DMO) policy response to these developments.

1 Gilts Market: Background

1.1 General background

The gilts market is a mature market; the first marketable British government security was issued in the eighteenth century. The current market structure of the gilts market was introduced in 1986, following the "Big Bang"; it has changed little since then.

1. The most recent survey by the Bond Market Association identified 74 systems offering electronic trading services in fixed-income markets.

* The complete version of this paper can be found at www.dmo.gov.uk.

Gilts trade relatively infrequently compared with, for example, the FTSE-100 stocks. There are, on average, over 26 times more trades a day in equities in London than gilts, but the average size of a gilts trade is over 80 times that of an equity transaction. This indicates that trading behaviour in the two markets is significantly different and that structures that work in one market may not work in the other.

1.2 Role of issuer

In April 1998, the DMO took responsibility for the issuance of U.K. government debt. Its key objective is to support the government's aim of minimizing its financing costs, taking account of risk. In addition, it has a strategic objective to maintain orderly and efficient markets and to promote a liquid market for gilts. A liquid gilts market should minimize the government's cost of raising funds by reducing some of the risks investors face, consequently reducing any risk premium that exists on gilts.

The general principles that guide the DMO in its approach to the creation of new trading venues are as follows.

(i) Liquidity and efficiency of the gilts market: The DMO would be concerned if the market became excessively fragmented or if liquidity was damaged significantly.

(ii) Orderly market environment: The DMO wants gilts to be traded in an orderly and regulated environment, ensuring at least some minimum degree of investor protection.

(iii) Entry/exit of gilt-edged market-makers (GEMMs): The DMO's ability to confer or to revoke the primary dealer status of any institution should not be constrained by any external influences.

(iv) Interests of retail investors: The manner in which these new trading venues would affect retail investors' ability to secure best execution and meet their need for transparency are issues that also need to be addressed.

1.3 The role of primary dealers

In common with many other government bond markets, the U.K. gilts market is characterized by the presence of primary dealers, the GEMMs. Due to the trading characteristics of the secondary gilts market, where the majority of investors may not be actively trading every day, there is unlikely to be an even flow of demand and supply of gilts. Therefore, the DMO considers that a system of committed liquidity providers, which bridge the gap between demand and supply, reducing execution risk, is beneficial to the secondary market.

In return for providing this market-making service in the secondary market, the GEMMs have special privileges with respect to auctions. The DMO also carries out a range of other secondary market operations exclusively through the GEMMs.[2]

The issuer also benefits in the primary market from the presence of primary dealers with some obligations to participate in primary issuance. This mitigates governments' event risk arising from adopting a transparent approach to primary issuance.[3] Primary dealers can also provide the issuer with a variety of useful market intelligence and act as an efficient distribution mechanism, facilitating the transfer of stock from the issuer to the end investors.

Overall, the DMO believes that a list of designated primary dealers is advantageous to both the primary and secondary markets. Therefore, it is likely that certain privileges in the primary market will continue (for the foreseeable future) to be linked to the provision of certain services in the secondary market.

There are currently 16 recognized GEMMs in the gilts market.

1.4 Role of gilt-edged interdealer brokers

Another feature of the gilts market is the gilt-edged interdealer broker (IDB) who intermediates exclusively between the GEMMs. Almost all trades between two GEMMs are intermediated by an IDB. These transactions make up approximately 40 per cent of total turnover in the gilts market.[4]

The purpose of the IDBs is to allow the GEMMs to unwind any unwanted positions acquired in the course of their market-making activities, within the closed environment of GEMMs. The IDBs act as principal to all trades, preserving post-trade anonymity. Trade information is kept within the GEMM community and is not disseminated to the wider market.

There are currently three endorsed IDBs in the gilts market.

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2. See "Official Operations in the Gilt-Edged Market: Operational Notice by the U.K. Debt Management Office," November 2001, for full details of these operations.
3. GEMMs are expected to participate actively in auctions and are expected to bid in line with their share of secondary-market trading. In the case of index-linked auctions, there is a target of 3 per cent minimum allotment set for index-linked GEMMs.
4. Based on data reported by the GEMMs for financial year 2000–01.

2 Gilts Market: Electronic Trading

2.1 The changing environment

A number of the GEMMs participate in existing fixed-income electronic trading systems, including interdealer platforms and multiple dealer-to-client systems.

Of themselves, these developments are to be welcomed where they improve the operational efficiency of the market and improve customers' access to liquidity. However, where they risk impairing liquidity at the core of the market, a policy response is warranted.

2.2 Policy response

In January 2000, the DMO published a consultation document that sought views on whether and how it should respond to the possible entry of electronic trading systems into the gilts market.[5] The consultation paper considered a number of different options, consisting of: no change in policy; the introduction of a centralized quotation system; the introduction of a centralized inter-GEMM market with quote obligations; and the introduction of a full electronic dealership market.

Responses were received from a wide range of market participants. The DMO considered these comments and identified its preferred approach in a response document issued in June 2000.

The DMO shared the concern of some respondents that no change in policy could add to the harmful effect of any possible market fragmentation. Therefore, the DMO decided to introduce an inter-GEMM market with mandatory quote obligations. These new obligations will require GEMMs to provide firm quotes to other GEMMs in a small number of benchmark bonds. The provision of mandatory quotes on a near-continuous basis will necessitate the adoption of some electronic trading technology.

This approach is similar to the mandatory liquidity provision common in most European government bond markets. The DMO believes that a central committed market will provide a benefit to the entire market, ensuring that GEMMs have access to a minimum depth of liquidity in certain stocks and that prices in that market are fully efficient, allowing the GEMMs to carry on their wider market-making activities in confidence. This will be of particular value in an environment where a number of (potentially exclusive) trading venues exist. The DMO hopes that this model will make it more

5. See "The Secondary Market for Gilts: A Consultation Paper," January 2000.

likely that entry barriers facing prospective GEMMs remain at an acceptable level, maintaining a high degree of competition in the provision of market-making services. This should ensure that any benefits resulting from the new system are reflected in the service that GEMMs provide to investors.

A working group of elected representatives of the GEMMs and a representative of the DMO considered the question of how these quotes would be provided to the market. This group has concluded that the best way is to allow each GEMM to supply their prices to any recognized IDB. Adopting this approach preserves competition in the provision of IDB services. This means that brokers will have a continuing incentive to develop and maintain an attractive service, encouraging further technological innovation.

The DMO plans to bring these mandatory quote obligations into effect early in financial year 2002–03. As noted above, given competition in the market-making sector, any resulting increase in liquidity in the inter-GEMM sector should pass through into the wider market.

Conclusion

Introducing new market structures to an existing market raises issues that differ from those that would be raised if it were a new market. Natural inertia and a fear of change can lead to significant switching costs; these need to be borne in mind when considering the appropriate policy response to the introduction of electronic trading.

As issuer, a primary dealer network provides an effective way in which to mitigate execution risk. The DMO continues to see an important role for the GEMMs; therefore, it needs to ensure that the GEMMs' cost and risk trade-off is maintained at a level that ensures the continued participation of a core number of dealers.

The DMO's initiative in the inter-GEMM market builds on the existing IDB structure but will hopefully create the necessary environment to encourage the natural development of more transparent and operationally efficient mechanisms such as multiple dealer-to-client trading systems. However, the DMO does not intend to mandate such developments.

While some GEMMs remain skeptical about whether the DMO initiative will improve liquidity in the IDB market, others, given their experience of European fixed-income markets, are more positive. It will provide a mechanism for a GEMM to unwind an unwanted position relatively easily and at a known cost. This should help risk management. In addition, it will provide greater transparency in that market, where few prices are currently posted.

Discussion

Charles Gaa

This paper is particularly interesting in that it describes a practical and pragmatic application to policy of many of the concepts presented at this conference.

I would like to draw your attention to a couple of the key issues raised in Allison Holland's paper.

- I will start by outlining the different types of electronic trading systems that are out there in global debt markets, and what they mean in terms of market structure.
- In this context, I will go on to discuss the policy response of the U.K. Debt Management Office (DMO) to the challenges identified in the paper, and attempt to demonstrate parallels between this response and the research that has been presented already this morning.
- Finally, I would like to step back and approach these issues from a slightly different direction and discuss electronic trading from a financial stability perspective—a perspective that we at the Bank of Canada bring to the table, in addition to that of a debt manager, which we share with the DMO.

Wholesale Debt Market Trading Systems

First of all, I'd like to examine electronic trading in wholesale fixed-income markets more generally. We hear from the Bond Market Association (a U.S. industry group) that there are about 70 systems out there, but how can we distinguish one from another? Which features are important?

There are at least two characteristics that differentiate wholesale debt systems:

- **Market function:** Is it a customer-dealer market, where customers trade with dealers to adjust their portfolios, or is it an interdealer market, where dealers trade with each other for risk-sharing and inventory management? This has implications for the size, frequency, and information content of trades.
- **Pricing mechanism:** Is it an order-driven market, where participants post public offers to trade, or a quote-driven market, where participants supply prices at which they are willing to trade?

This implies at least four categories of trading system, but I will focus here on the two that have been most successful in global fixed-income markets.

Multiple-Dealer Trading Systems

These systems essentially represent an automation of the bilateral, dealership, telephone-based market. Instead of calling each dealer in sequence to obtain quotes for a desired trade, customers can solicit quotes from several dealers simultaneously and then trade with the dealer of their choice. Customers have no opportunity to trade with each other, and eventual trade outcomes are known only to the customer and dealer involved.

TradeWeb has achieved a great deal of success in the U.S. Treasury bill market, and it is also now active in mortgage-backed, agency, commercial paper, and euro-sovereign securities. The system accounts for some 20 per cent of primary dealer trading in Treasury bills, with 18 dealers and 800 buy-side participants.

BondVision (formerly BondClick, recently acquired by MTS (Mercato Telematico dei Titoli di Stato)) and TradeWeb appear to be the front-runners in the European market. In Canada, CanDeal is a potential multiple-dealer system, although TradeWeb may also be considering entering the Canadian market.

These systems (and potential systems) are being offered by consortia of dealers, in direct competition with their other market-making activities. The intent would appear to be to ensure a seat at the table once the seemingly near-certain consolidation occurs. It should be noted that, in addition to participating in these multi-dealer systems, most bond dealers also now offer e-trading through a single-dealer proprietary system.

Electronic Interdealer Brokers

Representing a further automation of the screen-based voice brokers, electronic interdealer brokers (IDBs) allow traders to trade anonymously among themselves in an order-book-style market. Dealers also trade with each other bilaterally, just as in the telephone-based, customer-dealer market, although this has become less important over time.

Dealers use the interdealer market to manage the risk they incur through trading with customers. Interdealer trading is very important and may account for up to one-half of total trading volume. In the paper's U.K. setting, this is referred to as the inter-GEMM (gilt-edged market-maker) market.

The BrokerTec Global and eSpeed systems have gained some success in the U.S. Treasury market. MTS has been very successful in European interdealer markets, although BrokerTec Global may be making inroads. Interdealer markets are typically much more transparent than customer markets. In the case of the United States, and potentially Canada, interdealer trade information is made available outside of the interdealer market.

Market Segmentation

By combining Figures 1 and 2 to create Figure 3, we can illustrate the segmentation between the interdealer and customer-dealer spheres, and how these electronic systems correspond to debt-market structure. The upper half of Figure 2 is the interdealer market and the lower half represents the customer-dealer market. In general, the two markets are completely segmented.

In each sub-market, the existing structures have evolved to meet the needs of participants. The electronic trading systems that have been introduced in each segment correspond to the prevailing market structure. What sort of implications can we draw from this analysis?

Fragmentation or Consolidation?

One of the potential concerns with respect to electronic trading noted in the paper is fragmentation. Fragmentation occurs when market liquidity is split between two or more markets and orders do not have an opportunity to interact. Network economics tells us that, with markets, the whole is greater than the sum of the parts. When participants do not have the opportunity to interact, the overall quality of a market suffers.

Figure 1
Multiple-dealer trading systems
(e.g., TradeWeb, BondVision, or CanDeal)

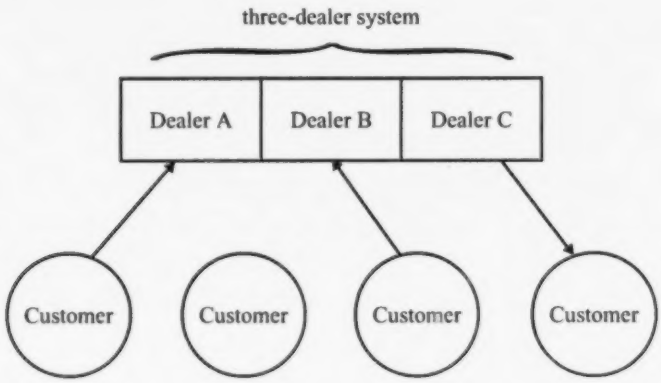


Figure 2
Electronic interdealer brokers
(e.g., BrokerTec Global, EuroMTS, or eSpeed)

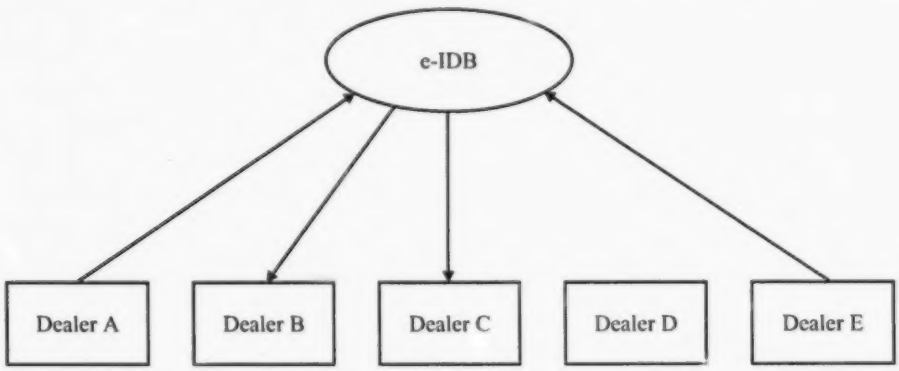
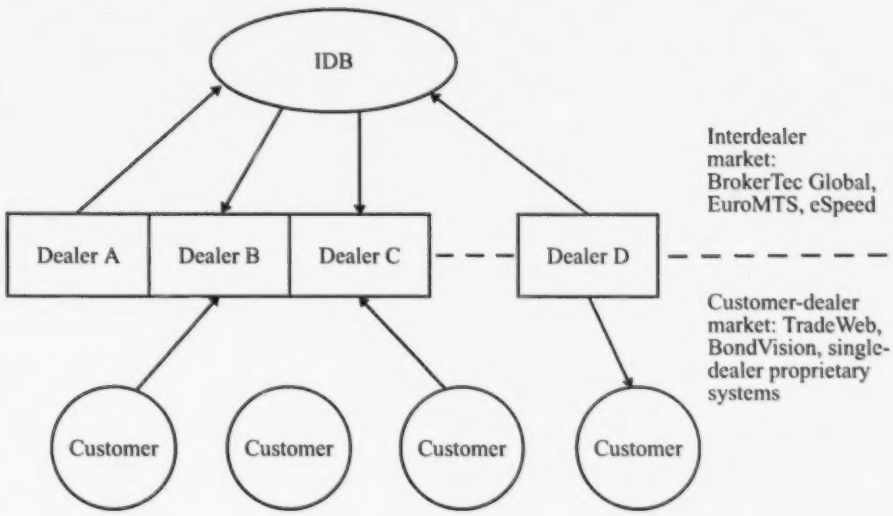


Figure 3
Market segmentation



On the face of it, to the extent that electronic trading lowers the barriers to entry for new markets, and may result in the introduction of new and competing trading venues, fragmentation would appear to be a real threat for debt markets. However, when we look at "markets" (i.e., debt, equity, or foreign exchange) not as homogenous units but as collections of discrete sub-markets, the potential impact of electronic trading becomes much less clear.

In other words, there is no existing centralized market in the customer-dealer segment that is in danger of becoming fragmented. In the interdealer debt market, however, IDBs are centralized markets and there is consequently some concern about fragmentation. This reasoning is consistent with the DMO's decision to introduce a central, committed inter-GEMM market, while leaving the customer-dealer market unchanged.

Transparency

Transparency is an issue that has received a lot of attention. Electronic trading has the potential to increase market transparency, but the appropriate level of transparency, as suggested in Toni Gravelle's paper (this volume), may depend on the market examined. Trading characteristics, such as frequency, size, and information content, seem to be important. With respect to the DMO's policy stance, this corresponds well to the differential transparency regime in the U.K. gilt market (as described in the Holland

paper), where (i) interdealer trades are transparent to the interdealer market only; (ii) wholesale customer-dealer trades are not transparent at all; and (iii) retail customer-dealer trades are publicly disseminated.

Policy Objectives and Implications

One question that may come to mind is: why are we interested in all of this? Market structure is important for liquidity and, in this context, the introduction of electronic trading is important insofar as it has an impact on market structure.

From a debt management perspective, policy that enhances market liquidity is vital to achieve low-cost financing, particularly in the face of declining government borrowing needs.

In addition to its role as fiscal agent for the Government of Canada, however, the Bank of Canada has a mandate to promote financial system stability, of which financial market stability is an important component. We believe that liquid markets are more resilient and robust in the face of financial crises than illiquid ones and, therefore, policy that promotes liquid and well-functioning markets is important from a financial stability perspective as well.

From a financial stability perspective, however, electronic trading is important for reasons beyond its potential impact by way of changes to market structures on liquidity.

In conclusion, I'd like to draw your attention to the policy issues raised by the following questions.

- How do these systems respond in times of crisis?
- Are they robust?
- What about contingency planning and backups?
- How do participants respond in times of crisis? Do they return to the old methods? Following the events of 11 September, for example, participants were able to fall back to the telephone market in many cases (fixed-income: eSpeed, TradeWeb). So what happens if electronic systems completely replace lower-tech alternatives?

General Discussion*

Commenting on Charles Gaa's last point, Allison Holland asked what happens when, or if, during times of crisis, backup systems such as telephone markets are no longer available. As she had mentioned during the discussion of the delivery of the inter-GEMM mandatory quotes, the market-makers were very keen on retaining a role for the voice brokers. Holland expected the existing IDBs to not only offer an electronic trading system but to also retain their voice-brokering desks, and this might make them more robust to times of market stress and market crises. She said that there is some brief evidence that after 11 September, EuroMTS and BrokerTec in Europe experienced a withdrawal of liquidity even though they continued to operate. They did not meet their purpose of allowing interdealers to manage their inventory risk as effectively as they had prior to 11 September.

Holland then returned to the idea of transparency. She thought that with the direction taken, one would see an increase in transparency in the market, in that some of the dealers who are supplying their prices to the central pool of liquidity will be very comfortable about supplying similar prices to a wider market. This raises questions about who benefits financially from data provision. One of the issues that market-makers in the United Kingdom feel very strongly about is that they own the prices, and if anybody is going to profit from selling these prices to Reuters or Bloomberg or whom-ever, that benefit should accrue to the market-makers.

* Prepared by Christine Bies.

Holland also touched briefly on the idea of direct access that came out of the Audet, Gravelle, and Yang paper. The authors were considering it in terms of allowing the large institutional investors direct access to the IDB segment of the market. Holland mentioned a consultation in 1998, on the role of the IDBs and perhaps extending membership of the IDBs. One of the things that came out very strongly in that consultation was that whether it be large institutional investors or just other wholesale market participants, the market-makers would perceive those players as fair-weather market-makers, and it's perhaps one way to think about modelling this. Basically, the dealers would require some relaxation of their market-making obligations to these new IDB participants. Therefore, from a large institutional investor's point of view, do they get more liquidity by being part of the IDB system (at the expense of losing their committed liquidity provision at other times), or does it make more sense for them to allow the exclusive club to continue but receive the benefit of committed liquidity provisions in the secondary market?

Lawrence Schembri noted that ten specialists in indexed gilts were mentioned in the presentation. He asked if there was any difference in the characteristics of the markets for indexed gilts as opposed to the other ones.

Holland responded that—in common with the situation in Canada—the index-linked market, characterized by the buy-and-hold investors, is even more illiquid than the conventional market. She said that there is very little free-floating stock around, and the activity is concentrated around the auctions, "so there's a peak of activity across all index-linked stocks when we're auctioning an IG, but then it's just deadly quiet, and therefore there's quite a lot of risk for the market-makers." If they're left with an inventory position following an auction, it's very difficult for them to unwind it, and they have to warehouse that position until the next event in the market. It is fair to say that there is quite a heterogeneous approach to inventory-risk management across our market-makers. In the United Kingdom, there are American dealers, European dealers, and U.K. dealers, and their approach is not exactly the same. Some of them definitely have much tighter controls on the exposures they can take and the length of time they can run those exposures. Therefore, they have varying needs for an effective secondary market.

Asani Sarkar spoke of the parallel with the U.S. case. He said that a somewhat similar issue came up in the U.S. government bond market. The response was to form GovPx, a central reporting agency that would report all the quotes—but there was no requirement to have mandatory quotes. Comparing the U.K. situation with that, the British authorities have gone

one step further by having a mandatory quoting procedure. Sarkar was curious to know the thinking behind that.

Holland responded that they did look at the U.S. model, and that one of the advantages the U.S. Treasury bond market has over the European markets is that it is much deeper and much more liquid. She added that it is interesting that there are no market-making obligations on the dealers in the U.S. market. It's a voluntary provision of liquidity, whereas in European markets, there is a mandatory market-making obligation. The U.K. authorities thought that they were closer to the European markets than to the U.S. bond market. EuroMTS, which has been very successful, first in Italy and now in the other European sovereign bond markets, is based on a notion of committed liquidity provision in the interdealer market.

John Murray felt that the perspective suggested by the discussion tended to be very national, rather than international. He said one could imagine an international pool of liquidity: all sorts of governments simultaneously issuing debt, wanting to minimize their financing costs, perhaps not even having the best claim to that lowest financing cost in the broader sweep of things. He asked whether there could be some danger in approaching this in a segmented, national perspective, as opposed to adopting something a little more global. Could there be something missed as each government and each regulator sits down and says "what suits my market?" What brought the issue home to him is the sense in Europe of national markets being forced to consider the broader picture and hoping that something bigger and better emerges. When one talks about numbers of dealers, who should be included—just the ones in one's national market, or those who potentially compete in less direct ways? Murray wondered whether the scope of the discussion is just a little too provincial.

Holland considered this an interesting point. She said that the British would like to encourage more international participation in their market. Their key investor base is domestic, and the market is dominated by the presence of the domestic pension fund and insurance companies. She mentioned the perception of the gilts market, of being a very odd local market with some very odd trading characteristics. She added, however, that she did not believe this to be the case any longer, since the conventions are now quite standard. Holland thought that if anything could be done to encourage the market-makers to be more active in promoting the market to their international clients, then that has to be beneficial, and it is only when heterogeneous investors enter the market that it becomes a much more naturally liquid market. Then one could begin to relax some of the forced liquidity provision mentioned here. She hoped that after a couple of years, the market-making obligations in the interdealer market could be eliminated

and that, for instance, the market-makers' concerns about the entry of international dealers into the market could be perceived as more of an opportunity than as a threat (as they currently are perceived because of this very fair-weather market-making).

Walter Engert brought up the paper's statement that the DMO does not have any specific target for the number of GEMMs, but that the author would be concerned if it fell into single digits. He asked what their response would be.

Holland replied that this is obviously something they hadn't thought about very clearly yet, but with a small number of market-makers, they may have a bit too much power in determining what the issuer does. She suggested that if this occurred, direct participation by the institutional investors at the auctions would be considered, moving a little bit away from using the market-makers as the exclusive distribution mechanism. She concluded by saying that it was difficult to predict what other changes might be introduced.

Liquidity, Transactions Costs, and Reintermediation in Electronic Markets*

Ian Domowitz

Electronic financial markets play an important role in the evolution of the industrial organization of the trading services industry. This paper focuses on the potential of electronic markets to lower costs to the trader, and on the implications of that potential with respect to the development of trading markets. This perspective leads not only to a discussion of the future of exchanges, but also of their new competition, novel forms of financial intermediaries.

Three questions motivate the analysis and contribute to a view of evolution in the market for markets. First, does trading in a venue characterized by automated trade execution result in lower costs to the trader? Second, what are the means, peculiar to electronic market design, that lead to cost savings? Finally, what do the answers to these questions imply about the nature of intermediation in an electronic environment?

Does Electronic Trading Reduce Trading Costs?

Globally, trading costs fell during the late 1990s. While explanations include competition for order flow, shifts in trading strategies to accommodate liquidity differences, more institutional trading, and pressure from new trading systems and regulatory authorities, much of the decline in trading costs must be attributed to the adoption of automated trading technologies.

* The complete version of this paper can be found at:
http://www.smeal.psu.edu/faculty/ihd1/Domowitz.html.

The paper gives the results of international cross-sectional regressions, based on quarterly data, of trading costs on volatility, turnover, market capitalization, and a latent variable indexing automation of trade execution. These results, which are economically and statistically significant, show that automation of trades reduces trading costs. The magnitude is about 33 to 46 basis points. Moreover, the paper cites studies indicating that fixed costs of setting up an automated trading system (on the order of $10 million to $100 million) are much lower than the costs of setting up a floor trading system (approximately $200 million to $400 million). In addition, the operating costs of an automated trading system are lower.

The paper then compares trading costs incurred through the use of four automated trading facilities (Instinet, Instinet Crossing, Posit, and AZX) to 34 traditional broker/dealer operations, and finds savings from automated trading in the range of 31 to 65 per cent. These results are consistent with others in the literature. The paper also finds that the cost savings of using automated trading systems are greater for more "difficult" trades, where greater difficulty is defined as larger trades, trades during times of market volatility, and trades of small-firm equities.

Through What Mechanisms Are Lower Trading Costs Realized with Automated Systems?

The paper suggests that the main mechanism leading to lower trading costs is strategic liquidity management. Since there are times during the trading day when trading is thicker and liquidity is deeper, strategic liquidity management refers to timing trades to occur during the most liquid periods. The use of an electronic order book facilitates this process by permitting real-time liquidity assessment and reducing the costs of monitoring the market. This process, then, further reinforces the clustering of liquidity supply and demand.

What Do Answers to These Questions Imply About the Nature of Intermediation in an Electronic Environment?

There is a misconception that electronic trading eliminates the need for market-making. Wherever a demand for immediacy exists, regardless of the trading venue, market-making activity will arise endogenously. However, this is not to say that market-making is always going to be at the core of the market.

Reduced transactions costs made possible by electronic trading systems do, however, suggest a declining scope for traditional brokerage services. One of the main points of this paper is that, rather than simple disintermediation or exiting from the market, brokers are reintermediating or re-establishing themselves in the new environment. The reintermediated brokerage could offer functions such as search, not just across counterparties, but across markets; analysis of trades based on such factors such as speed, cost, last sale, dealer activity, liquidity, and published quotes; and automatic order execution.

The services offered by an electronic exchange include: (i) automated trade execution; (ii) a quote and price server; and (iii) a hosting or "site" function. In other words, electronic exchanges are much like utilities—and they are potentially subject to the similar low margins and extreme consolidation of most utilities. However, advances in information technology (IT) suggest reintermediation by exchanges in the form of rebundling of the financial services offered. The new bundle can include repackaging and analysis of data, liquidity management support, as well as listing and trade execution.

Institutional traders have a demand for new order types and linked order destinations for contingencies. This suggests an open, modular IT architecture. Some reintermediation initiatives on the brokerage side include electronic matching agents, trade management facilities, and institutional support for trading and order-submission strategies. Others focus more on supporting portals to alternative trade execution venues. Open architecture brings about a smoother creation of connections between systems, for example, between equity and bond trading systems. On the exchange side, re-intermediation efforts involve using modular architecture to permit trading on various venues around the world. Traders would be able to connect their own front-end software directly to the system. Moreover, these systems can offer traders strategic liquidity-management support.

Conclusions

Electronic trade execution technology cuts the cost of trading, and much of these savings result from active liquidity management by system users. Moreover, these technological developments are causing traditional brokers and exchanges to adjust the mix of services they provide, and these reinter-mediating entities are focusing on the nexus between trade execution and investor decision support.

Will brokers or exchanges prevail? Exchanges appear to have the competitive advantage in terms of the development of real-time information and liquidity-management services. Reintermediated brokerages are grappling in another area, however. During the normal course of affairs, brokers bring orders together, searching for counterparties. If two orders do not match perfectly, the brokers can attempt to bring the two parties sufficiently close to make a transaction possible. This is called the "near-match" problem. The development of computerized negotiating systems to overcome this difficulty represents a new frontier in trading systems.

Discussion

Peter Thurlow

We are faced with an interesting dilemma when an economist takes one view, and a market participant, with real money riding on a position, takes the opposing view. Moreover, it is exceedingly rare for an economist to actually put real money on the line—but when that occurs, we should all sit up and take notice.

The paper covers three main areas. The first outlines the results of empirical work demonstrating that the advent of electronic trading reduces transactions costs. The second area discusses the implications of predictable time-varying market liquidity, and the third describes the prospect of "reintermediation." I will pass relatively quickly over the first section, since the results are largely intuitive, and the author not only presents his results, but he also cites substantial support in the literature. I think we can take it as given, therefore, that electronic trading leads to decreasing transactions costs. It is the second part of the paper that I found fascinating, and that is where I will focus my discussion.

Before doing so, however, I have a few questions regarding the first section. The author shows that the cost savings of using electronic markets is greater the more "difficult" the trade. ("Difficulty" here is defined by large trade size, trading of small-capitalization firms, or volatile market conditions.) I find that these results make intuitive sense if suitable counterparties can be found in those circumstances, because it is in these situations that illiquidity is most likely to pose a problem. The real question is whether the electronic trades were carried out with the same immediacy as the non-electronic trades. If there were differences in the quality of the transaction, the cost

difference could reflect, at least in part, the price of the trade quality, that is, the cost of market-making.

The second part of the paper discusses strategic liquidity management. This idea stems from the observation that there are times in the day when relatively more trades occur and, hence, the market is relatively more liquid. Traders are aware of this, and when strict immediacy is not required for a trade, they take advantage of the situation. Strategic liquidity management involves modelling the predictable elements of time-varying liquidity and determining optimal trading strategies with respect to given (large) trades.

The really exciting part of this paper deals with reintermediation. The author suggests that it is a popular misconception that the cost savings of electronic trading completely supplants the role of brokers. Although most financial markets function with some form of market-making, the central role of market-makers will change with electronic trading. The point is that an evolved and redefined version of the role of brokers will re-enter the market. These reintermediating entities would now offer strategic liquidity management support, as well as search, analysis, and dealing across different markets, rather than simply finding suitable counterparties. They would create electronic linkages between multiple order books, which would shift trading to times and venues where liquidity is the deepest, thereby enhancing peak liquidity, albeit at the expense of other times. Since more trading would be done when liquidity is greater, however, the average cost of trading would fall, and one would expect more trading overall.

Of course, the exchanges would not be sitting on their hands through all this. They would be redefining themselves as well. By leveraging their technologies, they can add data, analytics, and liquidity management to their output bundles. Moreover, using open architectures, the exchanges can allow portals to other markets and provide instantaneous market access to distant participants.

So, stepping back for a moment, the changes suggest—besides making more and better information and analysis available to market participants—the creation of greater linkages among markets, both across product type and geography, quite possibly fusing them. The stakes in these developments are potentially enormous, which easily explains the excitement and the frenetic pace of activity. Given the rapid technological advances, the rate of change in financial markets has accelerated. There is tremendous competition, and life cycles have been considerably compressed. Survival is likely to be reserved for only the most alert, nimble, and innovative. While most economists have been conditioned to think of a technological advance leading to a flurry of activity, which then settles down to a steady state, in this case, rapid transformational change is likely to *be* the new steady state.

But what does all this mean from a public policy perspective? The first question in this respect would be: is all this a good thing? In general, and the response is subject to several caveats, I think that the answer has got to be a resounding affirmative. The linking and fusing of markets bring us closer and closer to a single 7/24 global financial market. This development would have the effect of pooling the liquidity of existing markets, and that would lead to a deeper, more liquid market, which would, in turn, enhance efficiency and financial stability.

But what of the caveats? First, regulators and market overseers must also be alert and nimble. While they may not be able to lead the market, they must at least keep up. It would be useful to establish a dialogue with the markets so that those who do lead market developments are aware of the concerns of regulators, and also that regulators remain aware of upcoming developments. Regulators and overseers around the world should also maintain an active dialogue, with an eye towards standardization of regulation, since regulatory arbitrage becomes easier and easier as market interlinkage increases. Second, issues of systemic risk must continually be addressed, as the nature of the markets and participants continues to evolve. Third—and this is obviously a recent concern—the key market infrastructure, including clearing and settlement systems, as well as trading systems, must be risk-proofed against disasters, both natural and otherwise. All this should be done in a way that is technologically neutral, and that at least does not hinder desirable market innovation.

From a Canadian perspective, these developments would appear beneficial. Investors will have greater access to global markets (and also better information and analysis). Many issuers may find it easier to tap international sources of capital, and as long as Canadian participants keep up with developments and work with Canadian regulatory bodies to ensure that Canadian trading platforms are attractive to use, Canada's trading centre will continue to operate. However, would any market segments be left behind by these developments, and what would their prospects be?

In conclusion, this very interesting paper addresses primarily the implications of electronic trading for the structure and organization of financial markets. The developments suggested are positive, but do give rise to a number of regulatory and public policy questions that can have a significant impact on the continuing health of financial markets—and ultimately, the economy.

General Discussion*

Ian Domowitz responded to the discussion regarding the cost savings afforded by electronic trading by emphasizing that once the difficulty of the trade is taken into account, these cost savings are still there and can be broken down. He said that in terms of immediacy, comparing Archipelago with the NYSE floor, roughly 90 per cent of the Archipelago orders are executed in under 2 seconds, whereas less than 34 per cent of the NYSE orders are executed in less than 15 seconds. In other words, there is more immediacy from the electronic markets than from the floor.

Domowitz thought that it may be appropriate to regulate financial markets with respect to various areas of public concern such as fraud and fiduciary responsibility, but not to regulate market structure. He emphasized that the paper says that the market is going to take care of things competitively, and that regulation is most suited where some form of market failure is observed. It is not clear that market failure exists in the context of the structure of markets. He said that is certainly true in the United States, and probably in Canada, as well. He stated that this reintermediation concept—to the extent that it is actually being carried out—is providing increased levels of transparency for different types of trades and that this is good for the market. Domowitz suggested that best execution might be defined as what is best for the customer, as opposed to being pegged to any benchmark that happens to be good for one clientele and not necessarily good for all.

* Prepared by Michael King.

He said that with respect to linkages and associated tools—especially given the new Regulation ATS (alternative trading systems) that are being promulgated—the paper also suggests that there is no need to mandate consolidation. He added that the market is going to do that—the broader the market for the technology, the broader the market for the execution service—because the process of reintermediation is a profitable one. He thought it has already done so in the United States, and that it is happening in Europe, as well. He did not see any reason why it would not happen here in Canada.

Randall Powley noted that reintermediation implies recompensation. He asked whether the author saw that as being a natural evolving process. He said that there are some fairly complex structures in place for compensation, particularly at the institutional level, and that these could be related to the lack of penetration at the NYSE. Powley asked whether there are any problems.

Domowitz replied that some types of compensation are changing already, for example, with decimalization in the United States. He added that it is certainly common knowledge that market-makers have had a fairly hard time on the Nasdaq—pretty close to failure in some cases. This suggests that the compensation structure, which is basically not to charge a direct commission but to take it out of the spread, is no longer serving well, and neither is payment for order flow. He said that sort of compensation structure is rapidly disappearing, and we are starting to see charging of explicit commissions on Nasdaq. This, Domowitz felt, is a situation where things are happening by themselves, and he did not see anything wrong with either of those developments.

Domowitz then asked Powley if he was referring to the case where reintermediaries are supplying certain types of services and charging a commission for those services, and are they giving away the technology—and in a sense informally "softing" the product.

Powley wondered whether a firm could break into the soft-dollar business that is already established.

Domowitz said that the soft-dollar business that exists is largely in terms of third-party fundamental research on basic companies. He admitted that there is a certain amount of giving away of computers and that sort of thing, and that it is true that they hide certain costs relative to the end users of institutional investment funds, namely the retail people who are sending in their cheques to buy their shares. But, by and large, he did not see the softing activity increasing as a result of this form of reintermediation.

Powley asked whether Domowitz had any thoughts on the lack of penetration by electronic communications networks (ECNs) on the NYSE. Domowitz said that he did, but that it was not the puzzle that had been presented that morning. He felt that although ECNs are different and have different strengths, there is very little difference between electronic systems and trading floors in terms of market quality. He indicated that the NYSE is a remarkably low-cost provider for what it does, and that he did not see it going away any time soon. Furthermore, he added, since it is a low-cost provider and since liquidity is very centralized there, penetration in terms of market share has got to occur at a slower pace than would have been observed in an already decentralized market structure, where there was not a central mechanism for trading and where costs were extremely high on average, namely the Nasdaq. He said that even though Instinet has been around for a very long time—in principle, since 1969—and has been a so-called ECN since 1986, ECNs really only burst on the scene with the order-handling rules in 1997.

Domowitz said that ECNs were attempting to break into a relatively high-cost market with a very low-cost product, which was fairly easy. He thought that they have done remarkably well in achieving what they have in so little time, and that some ECNs—most notably Archipelago, which was just registered by an exchange in the United States—are now wanting to crack the listed market. He indicated that this was the first explicit run on that market, and that it was a business decision that hadn't been taken before. But, he noted, sufficient time has not yet elapsed to allow one to draw any conclusion as to what the action will be. He added, however, that the NYSE is a low-cost provider; liquidity is concentrated there, and it will be a tougher nut to crack. While electronic markets will not supplant everything, he said, it is certainly true that a lower-cost provider that can pass on those cost savings and a community of intermediaries that can support those market structures will cause a change.

Asani Sarkar asked Domowitz what role he saw for electronic trading systems where customers are interacting directly with each other. He added that it seemed that implicitly underlying the presentation was the idea that those kinds of systems would have a very limited role in the future.

Domowitz agreed that their role would be limited. He did not think it was simply the issue of the provision of capital. He said that firms can certainly make markets very effectively with electronic systems—it is done all over the world—and market-makers can easily use electronic systems that cater to direct access by retail clientele. But why isn't that going to happen? He said it was a fiduciary problem. For example, e-Bay is wonderful, but would you buy several thousand shares from person X on the basis of a goodness

rating on e-Bay? Probably not, he suggested. He also doubted that the regulators would allow it.

Domowitz concluded by saying that any electronic system that hopes to solve the retail-to-retail problem without intermediation by some form of broker is going to have to solve the "deep-pockets problem." The system would have to provide a mechanism to automate what amounts to the good faith and responsibility that the broker takes on with respect to making good on the trades. He added that Instinet invested quite a bit of money—it is said to be on the order of $40 million—in such an endeavour and, to the best of his knowledge, has cancelled the project. He said that it is a very difficult problem to solve because it goes beyond the execution process, and it would take true automation of the clearance and settlement system from the point where the customer signs up as a subscriber, right to the end. He said, however, that this isn't a problem for institutions, and that institutional trading is common.

Should Securities Markets Be Transparent?*

Ananth Madhavan, David Porter, and Daniel Weaver

Financial markets have traditionally been viewed as providing a function of price discovery, i.e., finding prices that equilibrate supply and demand. Another objective of markets is to assist in the process of capital formation. Secondary markets allow initial purchasers of claims to exchange these claims at fair prices should their investment objectives change.

While efficient price discovery is crucial, there is another equally important attribute of markets that merits consideration, namely liquidity. Efficient prices, after all, are unimportant if one can transact only a 100-share lot at these prices. Liquidity was historically provided by dealers who buy or sell securities on demand. In the past, where communication links were poor and buyers and sellers had little information about current market prices, it made sense to rely on dealers who stood ready to buy or sell on demand by posting bid and offer quotes. In the modern world, advances in communications technology allow buyers and sellers to interact with one another at current prices in an electronic auction without the need for a physical exchange floor or for dealer intermediaries.

The electronic or automated auction is widely used to trade equities, derivatives, bonds, and foreign exchange. In this model, liquidity is supplied by public investors rather than by dealers. But how to attract liquidity? Investors will move to a venue that provides what they want. For institutions, these requirements include:

- direct access, electronically;
- automation;

* For complete paper, see conference draft version.

- low cost;
- priority rules to give limit orders a chance to meet market orders;
- hidden orders;
- significant tick size that protects limit orders;
- anonymity, pre- and post-trade;
- an optimal level of transparency.

Of these, the last attribute is especially significant. Market transparency refers to the ability of participants to observe information about the trading process. An especially important aspect of transparency concerns the effect of widely publicizing information about investors' latent demands present in the limit-order book. This topic lies at the heart of controversial debates (regulatory, academic, and practitioner) about floor versus automated trading systems, the informational advantages of market-makers, and inter-market competition between trading systems with different levels of transparency.

Some regulatory responses to transparency questions have been predicated on the belief that greater transparency will increase the efficiency and fairness of securities markets. For example, both the U.S. Securities and Exchange Commission and the U.K. Office of Fair Trading have called for increases in transparency in their respective securities markets as a way of improving market quality. However, this salubrious view of transparency is not universal. The U.K. Securities Investment Board, for example, opposes increases in transparency; it contends that transparency increases will reduce liquidity, since market-maker positions must be publicly disclosed. Harris (1996, 1997) develops a similar argument where changes in transparency alter a trader's ability to strategically expose orders, which results in increased transactions costs or reduced liquidity when trades are withdrawn to avoid revealing orders to parasitic traders. Given the controversial positions and the significant theoretical research in the area, it is unusual that O'Hara (1999) points to the lack of empirical evidence that transparency "matters" in the sense that it affects liquidity, transactions costs, and hence asset values.

Experimental (laboratory) studies offer considerable promise for understanding the more subtle aspects of transparency. In an experimental study, human subjects trade in artificial markets, allowing researchers to study the effects of changes in information in a controlled setting. The ability to frame controlled experiments also allows researchers to gather data on traders' estimates of value over time, their beliefs regarding the dispersion of "true" prices, and the trading profits of various classes of traders. Recent

experimental studies confirm that transparency matters and often in very complex ways.

Experimental studies do not duplicate natural environments, but the importance of experimental research is heightened by the lack of natural experiments where markets have made exogenous changes in transparency. The few natural studies of transparency have generally focused on post-trade transparency, such as the issue of delayed trade reporting where natural data exist. Yet pre-trade transparency is as critical—if not more so—to the provision of liquidity and hence to intermarket competition. Pre-trade transparency issues permeate debates on the willingness of investors to supply liquidity through limit orders, the growth of upstairs (off-exchange) trading, the desirability of pre-announcements of intentions to trade (sunshine trading), the nature and extent of disclosure of order imbalances at openings or trading halts, and most recently, the choice of floor-based or automated trading systems.

In an ideal environment, pre-trade transparency would be studied during *changes* in transparency regimes, using natural experiments to examine prevailing theory. Although experimental studies are appropriate when natural experiments are not available, a natural experiment occurred on 12 April 1990, when the Toronto Stock Exchange (TSE) instituted a computerized system to disseminate real-time detailed information on the limit-order book to the public. This rule change applied to both the stocks traded on the TSE's floor (the more actively traded issues), as well as to the less actively traded stocks traded on the TSE's computer-aided trading system (CATS), and the rule change allows us to study the impact of a dramatic increase in pre-trade transparency on *the same stocks in the same market structure.*

Beyond the rarity of such a change in transparency regime, the TSE's protocol change is of special interest for several reasons. First, the TSE's CATS, instituted in 1977, is the blueprint for most automated trading systems in existence, most importantly the Paris Bourse. Thus, the experience of the TSE has implications for many existing markets worldwide.

Second, the wide cross-section of stocks in our sample allows us to make inferences regarding the effects of changes in liquidity and transactions costs on asset prices, a topic of considerable research interest.

Third, the protocol change allows us to isolate the effects of changes in disclosure across two systems *that already differ in the amount of transparency they offer.* In particular, the TSE's floor resembles the NYSE (New York Stock Exchange) in that *only* the registered trader—the TSE's

equivalent of the NYSE specialist—observed the limit-order book. By contrast, CATS already offered a high degree of transparency to all members, but not to the general public. Of course, these two systems are in no way intended to be controls in our study.

Fourth, some Canadian securities are traded in U.S. markets, which allows us to study the effects of changes in disclosure on cross-border order flows without complications arising from time-zone effects. Such an investigation sheds light on the effects of global competition for order flow among markets with different disclosure regimes.

Finally, the TSE's transaction data allow a detailed analysis of the effects of changes in transparency across "internal" dimensions.

Regulatory interest in pre-trade transparency stems from the differences in transparency that exist both nationally and internationally. Automated limit-order-book markets (e.g., Paris Bourse and Toronto CATS) disseminate not only current quotes but information on limit orders away from the best quotes. Consequently, these markets offer higher degrees of transparency than U.S. markets, which generally display only the best bid or offer. U.S. markets are either fragmented, screen-based markets (Nasdaq) or floor-based markets—NYSE, AMEX (American Stock Exchange), CBOE (Chicago Board Options Exchange), CBOT (Chicago Board of Trade). In floor-based markets, customer limit orders are held either by a specialist in a central book, which is not publicly revealed (NYSE, AMEX, and regional exchanges), or by individual brokers and not revealed to the market (CBOT). The exception is the CBOE, where the "book" of customer limit orders can be viewed by traders on the floor. Hence, the CBOE has the highest level of pre-trade transparency among U.S. exchanges. These differences in transparency pose a dilemma for regulators and policy-makers, because they complicate the task of integrating financial markets, both within the United States and internationally.

Academic interest in transparency is reflected in a rapidly growing theoretical, experimental, and empirical literature on the relationship between information and security prices. Previous theoretical research finds that transparency (i.e., providing information about traders' identities and motivations for trade) affects various dimensions of market quality, including liquidity, trading costs, and the speed of price discovery. Models by Pagano and Röell (1996), Chowdhry and Nanda (1991), and Madhavan (1995, 1996), among others, reach mixed conclusions regarding the effects of transparency. The lack of consensus arises because transparency admits many definitions as well as the difficulty in modelling behaviour (designing experiments) when traders' strategies are endogenous to trading protocols and information. None of these papers, however, explicitly addresses the

type of pre-trade transparency (i.e., public display of limit-order books) examined here.

Our analysis begins with a simple framework within which we explore the issues raised by the public display of limit-order books. Theory suggests that greater transparency of this form will result in more efficient order placement by market-order traders. Since trading is a zero-sum game, this gain in expected profits is associated with larger losses to liquidity providers if the limit-order book remains as deep as before. It follows that liquidity providers will be less willing to provide free options to the market in the form of limit orders and, hence, that spreads will widen.

Our empirical results strongly support the view that transparency matters in the sense that it has an economic effect on trading costs and liquidity. We find that higher transparency does *not* improve market quality. In particular, our analysis shows that transactions costs increase after the introduction of the rule change, even when controlling for other factors that may affect trading costs, such as volume, volatility, and price. This finding is consistent with a decrease in liquidity under transparency because limit-order traders are reluctant to offer free options to other traders. Cross-sectional evidence shows that the reduction in liquidity and increase in transactions costs are associated with reductions in asset values, consistent with the predictions of Amihud and Mendelson (1986) and Brennan and Subrahmanyam (1996). There is no evidence, however, that spreads of cross-listed stocks widen in other markets, nor is there any significant order-flow migration from one exchange to another. We discuss the implications of these results for public policy, including issues relating to intermarket competition between trading systems with different levels of transparency, public display of limit-order books, and the design of automated trading mechanisms.

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Discussion

Robert White

It is a pleasure to be here and a great honour to comment on a paper prepared by such distinguished authors. This paper is well-written and ambitious, and it addresses a very important issue in an actively researched area. As we saw from the papers presented earlier today, the subject concerns an industry that is undergoing tremendous change. The authors have raised a lot of questions, and my comments are meant either to build on what they have presented or to serve as suggestions for future work.

The question addressed by the paper is whether market quality has been enhanced or degraded by making the consolidated order book more transparent. The authors used several measures of market quality: quoted spreads, effective spreads, and volatility. The quoted spread is the inside quote on the book, and the effective spread is the change in the traded price relative to an equilibrium price. The authors used a number of univariate and multivariate tests to answer this question. The event that they examine occurred on 12 April 1990, when the order book was opened up somewhat, not completely, but by four ticks. Therefore, instead of simply having the market quote being shown, it was four ticks out on either side. And at that time, the tick was one-eighth, which means 50 cents up and 50 cents down.

But why was it four ticks? I expect it was because market orders on the floor walked out the book four ticks.[1] That is, large market orders often consumed

1. Walking out the book four ticks refers to the quantity of limit orders consumed by a given market order, in price space. When buying or selling shares, a person can submit a limit order, i.e., a price-quantity combination, which is relatively passive, since it simply goes onto the order book. A market order is more aggressive, however; it transacts with existing limit orders at the best price(s). Thus, when a market order "walks out the book," it is of such a magnitude that it consumes existing limit orders and moves the market price out on one side of the market.

limit orders and moved the price by four ticks. It was simply a market-making mechanism. And I believe this is an important issue that was not raised.

The authors used a control group from the computer-aided trading system (CATS). However, market orders on CATS and market orders on the floor were treated differently. The former do not walk the book. They can only go right into the book. That can have quite a different impact on performance.

Instead of the authors' "control-group," I would use the term "quasi control group." For example, the stocks listed on the exchange in the CATS trading venue are quite different from those on the floor. They tend to be smaller, more illiquid, thinly traded firms. The more actively traded, larger firms are on the floor. Another difference is that the floor walks out four ticks and CATS walks out only one tick. Moreover, the Registered Trader, the specialist equivalent, differs on this venue (versus the floor venue).

The authors' main conclusions are that the costs have been augmented and that volatility has increased as a result of increasing the disclosure on the book by four ticks. The authors conclude that market quality is inversely related to the degree of transparency—the more opaque the market, the better. And I believe this to be a reasonable conclusion.

One should be cautious about interpreting these results, however. This was a single event, and other factors could have played a role. In other words, you have to control for everything but that single event, and that is what the authors attempt to do with the control sample. Consequently, the differential impacts are important.

The early 1990s were characterized by significant events such as the Gulf War. Canada was on the cusp of a major recession. These kinds of events would be impounded into the price and they would most likely have an impact on the spreads and on volatility. The question is, do they, in fact, have a differential impact across the two sets of securities—the authors' control group and their test group. The mix of the securities in the two groups and the qualities of those securities are very important.

While I haven't gone back and re-estimated all of their data, I have looked at data from the spring of 1990. Basically, the February-March period is the authors' pre-period, and May-June is their test period. The patterns of returns on the overall index are drastically different and that is why they want the control sample. But can one obtain this perfect control sample and make it work?

The sample can be split into one index for securities trading under two dollars and another index for trading over two dollars. (The small firms are typically under two dollars.) The price level and firm size are highly correlated. But the pattern of returns for the small firms with the low-priced securities is dramatically different in the test period than it is for the large firms with the high-priced securities. That would lead one to find the floor securities to be of a higher cost, which is what the authors found. It doesn't prove anything, but it does raise questions that the authors might want to explore.

The volume of trading also has some bearing. What is interesting is that the trading bottoms out in April, which is the time of their event. Now, there are two reasons why this might be significant. If there is a trend in the volume of trading, then the issue of the four-ticks market order might become important, and it could drive the volatility of the floor to a greater extent than the volatility of CATS because of the ability of the market orders to walk the book. So, if there is a trend, one might expect to find pressure in that direction. The other sort of thing that differs between CATS and the floor is that the floor has an open outcry. Thus, there is a possibility for imitation trading on the floor. Papers have been published indicating that imitation trading is real and, consequently, any trends would increase volatility.

I would like to make some suggestions regarding an additional test for the quoted spreads. The narrower the quoted spread, the more efficient the market is, theoretically, and the lower the potential transactions costs. Another way of testing for the quoted spreads is to examine the duration when the bid-ask spread is wide and when it is narrow. Industry calls this a time-weighted average, and it is used as a statistic to compare securities, to compare markets, and to look at the difference and means tests to discover which market is more efficient.

One other statistic that is widely used is price continuity. Trading is all about being able to make trades at the desired quantities without significantly moving the market. One measure that the industry uses is price continuity, which is the percentage of the trade that is within five cents of the previous trade. The higher that percentage, the better the market. The TSE, for example, runs about 97 per cent price continuity, which is quite efficient. Once again, a difference and means test could be set up to determine whether or not a change in price continuity is significant.

One could take a variant of the authors' model in order to use the spreads as the dependent variable and to use trade-by-trade data (because the authors want to test for volatility) to set up a GARCH[2] model with a variance

2. GARCH: generalized autoregressive conditional heteroscedasticity.

equation in it. One would put a shift variable in the price equation for the floor versus CATS, and then put a shift variable in the variance equation to indicate whether the variances have increased or decreased. It seems to me that this becomes a more powerful test, since one can now control explicitly for information effects, size of orders and firms, and price volatility on a trade-by-trade basis.

Another problem with the authors' results is that they are based on an average equation. The average price is typically correlated with the average firm size, but firm size is also highly correlated with average volume. One would therefore expect the average price and the average volume to be highly correlated. If they are, that indicates an econometric issue that could distort the results. A correlation matrix would indicate whether or not the use of the average price is valid.

These comments are simply meant to be suggestions on extensions. Overall, the paper is well-written and the conclusions are reasonable.

General Discussion*

Mark Zelmer suggested that transparency may have different effects upon liquidity and market functioning during normal times and during times of crisis. Thus, he added, if the effect of transparency is positive during crises, even as it might have a somewhat negative effect during normal trading, we could look at it from a systemic risk point of view as an "insurance premium" of sorts.

Ananth Madhavan added that looking at the effect of transparency on market liquidity from a market perspective, a limit order is a free option to the market at large. In times of stress, he said, the value of that option increases.

Jon Cockerline said that when the TSE moved from CATS1 to CATS2, there was a change away from hidden orders. Since the group of securities remained constant, this episode might serve as a good "controlled experiment" to test the impact of a change in transparency.

Ananth Madhavan responded that this sounded like a good suggestion, although he was not sure that the data were available. He pointed out that here, as elsewhere, it is always possible to extend the work, expand the data set, and so on. He encouraged others to pick up where this paper left off.

* Prepared by Charles Gaa.

The Effects of Bank Consolidation on Risk Capital Allocation and Market Liquidity*

Chris D'Souza and Alexandra Lai

Historically, regulatory restrictions in Canada and the United States have inhibited the ability of financial institutions operating in one area of the financial services industry from expanding their product set into other areas, but deregulation has allowed these institutions to offer a broader range of banking, insurance, securities, and other financial services.[1] At the same time, deregulation in the industry has increased competition, prompting financial institutions to look for new, profitable lines of business. Some institutions have found it advantageous to merge in order to generate higher returns through economies of scope or scale. The impact of consolidation on market liquidity in government securities and foreign exchange markets is of immediate concern to policy-makers. Ensuring liquidity in these markets is important to governments and central banks interested in maintaining or enhancing the functioning of these markets so that they can effectively implement fiscal and monetary policies. In Canada, policy-makers are concerned about the declining number of dealers in Government of Canada

1. Prior to reforms undertaken in 1987 and 1992, the Bank Act and provincial legislation enforced the separation of financial institutions in Canada into five principal groups: chartered banks, trust and loan companies, co-operative credit movements, insurance companies, and securities dealers. In the United States, the Glass-Steagall Act of 1933 sought to impose a rigid separation between commercial banking and investment banking; the Act limited the ability of banks and securities firms to engage directly or indirectly in each other's activities.

* The complete version of this paper has been published as Bank of Canada Working Paper No. 2002–5. The electronic version can be found on the Bank of Canada Web site.

fixed-income markets and foreign exchange markets, and they worry that increased consolidation among financial institutions will cause liquidity in these markets to fall.

This paper analyzes the impact of financial consolidation on market liquidity by studying the effects of consolidation on the risk-bearing capacity of market-makers (or dealers) in dealership markets. To carry out our analysis, two previously separate areas of research are bridged. The first, market microstructure theory, focuses on how market participants and the trading mechanism affect price discovery and market liquidity. The second, risk management, influences the way in which firms look at the returns and risks of individual business operations. Our analysis traces the impact of a merger on the capital-allocation decisions of the new, merged financial institution and the resulting change in the behaviour of dealers.

Effective risk management promotes stability in financial institutions and the industry itself by protecting institutions against market, credit, liquidity, operational, and legal risk. This protection is obtained primarily through the maintenance of an appropriate level of risk (or economic) capital by financial institutions. The risk-management process involves estimating how much risk each business unit or division contributes to the total risk of the firm and thus to overall capital requirements. Capital held by the firm is then "allocated" across divisions. Since investment decisions and risk exposures are determined at the division level, correlations between portfolios held by different divisions are externalities among units that create a need for centralized risk management. Hence, the optimal capital allocation induces the appropriate risk-taking behaviour of division managers by forcing them to take into account the externalities their division imposes on the rest of the firm.

Using a model in which a financial institution allocates risk capital across its business activities to satisfy a firm-wide capital requirement, we show that the optimal capital allocation is a linear function of the division's risk-taking, measured by the variance of cash flow from that division, and that the allocation depends on correlations in cash flows across all divisions. Furthermore, it can be shown that capital allocation influences the risk aversion of division managers and traders. This key result relates risk management by the bank to the behaviour of its market-makers in asset markets. The risk-bearing capacity of a dealership market depends on the number of market-makers present, as well as on the risk aversion of each market-maker. Since market liquidity in dealership markets is determined by the inherent riskiness of the market and the risk-bearing capacity of the market, capital allocation affects market liquidity by influencing the risk aversion of market-makers.

Market liquidity is influenced by the way the market is structured. For example, most foreign exchange and government bond markets are characterized by price competition (quote-driven) among multiple dealers and interdealer trading rather than by Cournot competition (order-driven), and the actions of the dealers in the public and interdealer markets provide much of market liquidity. Such markets are referred to as dealership markets. This paper develops a dealership market model similar to the framework of Vogler (1997). However, we allow for heterogeneity among dealers with respect to their risk-bearing capacity. In general, market liquidity, measured by the bid-ask spread, depends on the risk aversion of all dealers in the market. The dealer with the lowest risk aversion (or the largest capacity for bearing risk) is able to offer the best price and receives public orders. This is the price at which customer orders are transacted and this price is decreasing in the risk aversion of the least risk-averse dealer, all other things being equal.

We apply this framework to examine the effects of financial consolidation on market liquidity. We assume that when two banks merge, the end result is a bank with a larger set of business lines or divisions. Clearly, the merger will have an impact on the level of risk capital allocated to market-making. We find that consolidation has an ambiguous effect on market liquidity. In particular, market liquidity can increase upon consolidation. Whether this happens depends on the correlation among the cash flows from the merged bank's division. This is in contrast to other results in the literature, which argue that market liquidity will necessarily deteriorate with consolidation. These other studies consider only the effects of a reduction in market-makers on risk-sharing, while our paper shows that the effect on liquidity of a bank merger will also depend critically on the risk-bearing capacities of dealers belonging to the banks before and after a merger.

Figures 1 to 4 illustrate our point: that a merged bank is more likely to allocate more capital to market-making when there is a negative correlation between market-making and the new activities of the bank, resulting in a decrease in the risk aversion of the dealer owned by that bank. Market liquidity improves (bid-ask spreads fall) following a merger if this decrease in risk aversion is large enough and if the initial number of dealers is large. Thus, a negative correlation between market-making and the new activities of a merged firm suggests the possibility of increased market liquidity.

Figure 1
Risk-taking in market-making, ρ = 0.5

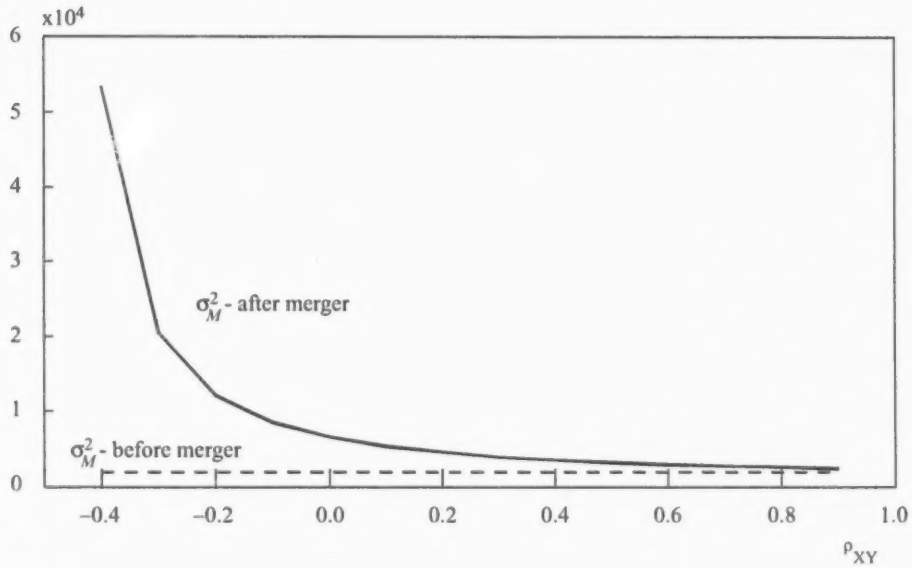


Figure 2
Risk-taking in market-making, ρ = 0

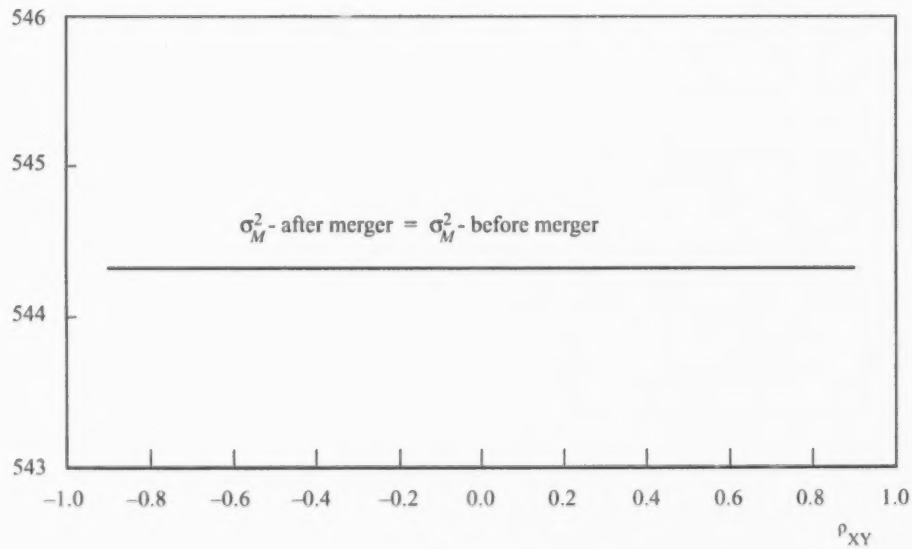


Figure 3
Risk-taking in market-making, $\rho = 0.5$

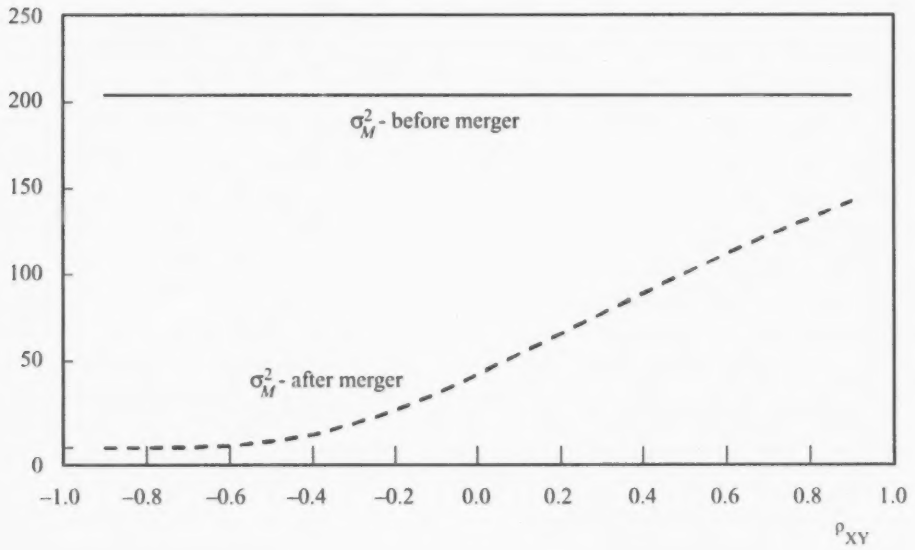
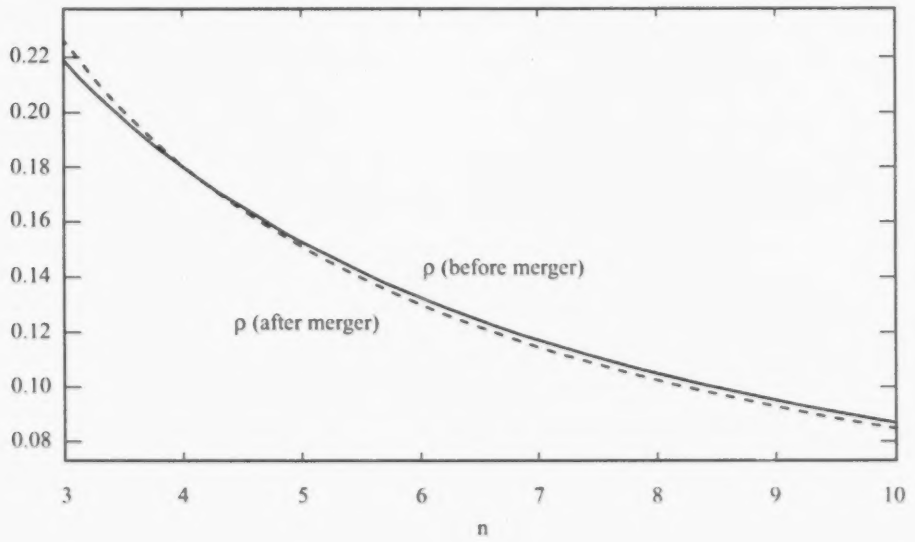


Figure 4
Equilibrium price (spread) in public market, $\delta = 0.4$



A greater amount of risk-taking following a merger corresponds to a decline in the risk aversion of the dealer or an increase in capital allocated to market-making. Note that when the cash flow from market-making is negatively correlated to that from the rest of the bank, $\rho < 0$, risk-taking in market-making always increases after the merger; and when that correlation is positive, risk-taking in market-making declines. Risk-taking in market-making is unaffected by the merger only when market-making is uncorrelated to the rest of the bank.

Figure 4 shows that when the dealer belonging to the merged bank sees a decline in his risk aversion, the equilibrium market price (and spread) can be lower after the merger when the number of dealers to begin with, n, is large enough. In this case, market liquidity improves for $n > 4$.

In conclusion, a merger between two financial institutions can improve market liquidity in dealership markets, even in highly concentrated markets, if the merger results in a significant increase in the risk-bearing capacity of the market through an increase in capital allocation to market-making by the merged bank. Whether this occurs or not depends on the degree of economies of scope between market-making and the other activities of the bank. Our results suggest that policy-makers and regulators faced with a proposed merger between banks would want to examine the correlations among division cash flows.

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Discussion

Gerald Goldstein

I approach this topic from a slightly different perspective, from that of the regulator. This perspective focuses on the institution, and for regulators liquidity means: can the banks generate enough funds to keep themselves solvent if people want to withdraw funds? This then relates to market liquidity. People can go to the markets to obtain liquidity, but markets are not the only source. Before going on, I would like to say that I am in complete agreement with Ian Domowitz: there seems to be a lot of searching for public policy issues here that could really be left to the market. Consequently, while some of my comments are going to concern the theoretical implications of this paper, I am not sure how empirically relevant they are.

The D'Souza and Lai paper addresses the accepted wisdom that a decline in the number of dealers will lead to a reduction in liquidity. With a neat twist, the authors show that this assumption may or may not be valid, through the one key tool that we have in finance theory—diversification. That is the essence of power in finance: diversify and you get a lot of results. The authors have admirably demonstrated that if you take a bank—or any financial institution, for that matter—and combine it with an organization that has activities that have a negative covariance with those of the bank, you are going to make the institution stronger, and you may generate more of the activity that you want. This is a nice result.

Let me suggest some context for their result. The authors have used a partial-equilibrium comparative-statics framework, which leaves some interesting extensions for them to pursue. If we started with an unconstrained world, profit-maximizing firms would seek the optimal combination of activities to engage in. The authors optimize over a subset of activities, "J" and "K." But, as Alexandra indicated, "J" is a decision

variable as well. They worked with "J" given. But since "J" is actually a decision variable, the intriguing question is what was the constrained-equilibrium distribution of activities before the situation that the authors describe?

We have clearly relaxed something in this model. It was allowing banks to take over dealers. But one empirical implication can be learned from "revealed preference." If, in fact, the state of the world before the one that the authors deal with was one in which no dealers merged, then there were no economies of scope among dealers. Moreover, there were no economies of scope among dealers and the unregulated sector either.

Some interesting empirical questions or implications could be pursued from this point. If banks take over some dealers, for example, somebody else was not doing it.

Furthermore, as the authors note, while the capital requirements of banks are determined as a fixed proportion of the risk contained in the banks' portfolios, firms often maintain capital levels over and above that amount to finance operations. However, the level of risk that a bank chooses is also endogenous. While the regulator targets capital for possibly minimum investment grade, banks endogenously choose the level at which they want to operate, and that affects the amount of risk they face and the way they deal with it. For example, internationally active banks choose to operate above the capital levels that we mandate because they are dealing in markets that are regulated by the market—by Standard & Poor's, Moody's, and Fitch ICBA, etc. And these regulators are more demanding and require higher capital levels than we do if the banks want to trade with one another. So, the optimization problem becomes even broader. But it also becomes endogenous.

Before continuing, I would like to repeat that we should be wary about providing an excuse for expanding public policy. The model is set up and the text is written such that there is a social benefit from having a liquid market in selected securities. Government securities markets perform several important functions that hinge on the fact that they are very liquid. Otherwise stated, there is a strong externality to the private decisions of dealers. In fact, we can go further than that. This is the polar case of the externality of the pure public good because there is no excludability. It is a non-rivalrous risk commodity, which implies that there is a suboptimal amount of government interference in this market. But if a case can be made that effective government policy needs effective dealer markets, then the objective function in this paper is only a private optimum and it needs to be respecified to achieve a social optimum. It is very important to establish

empirically that we do, in fact, need effective dealer markets to transmit public policy. But if that is the case, we are not achieving a social optimum.

The key to the argument in this paper is that the cash flows from a specific activity have a negative covariance with another activity. It would be interesting to hear more about the source of that covariance. The literature on market liquidity draws on two motives for dealers—asymmetric information and inventory control. What are the sorts of activities that co-vary with market-making within a bank? A paper by Huberman and Halka (2001) tried to estimate systematic risk and return, and although the authors were not very successful, they did make an attempt. And they raise an interesting point: "Although market makers seem central to current models of spread and depth, the effect of their presence on spread or depth in actual markets is not obvious. For instance, the bid and ask prices and quantities shown by New York Stock Exchange (NYSE) specialists are not necessarily their own, but often are those of other traders with no special status in the market." So it is not even clear empirically how we are going to get at some of this.

This is not a literature I know well, and one of the papers I read to introduce myself is by Maureen O'Hara (2001). She makes an intriguing comment that links to this paper: "Multi-market linkages introduce complex and often conflicting effects on market liquidity and trading behaviour. Indeed, it is not even obvious whether a segmented market equilibrium is sustainable." This raises a question within the partial-equilibrium context. When we go to the multi-product firm, is a market equilibrium sustainable? Most of the literature is done in comparative statics and there are fascinating stories about the tatonnement process within, but it becomes very difficult to implicitly model what is going on there.

I will close with a comment about banks and their response to capital requirements. Banks are profit maximizers and if you regulate a bank, it will find a way to optimize, subject to that regulation. This does not always mean adding activities. It often means offloading to get around constraints. And it also means creating liquidity. We often forget the ingenuity of private market institutions in creating liquidity. Financial institutions have learned how to take a product—a government security—and slice it into end products. The institutions then take the return on that product and trade it; they take the volatility of the product and they trade it. They simply swap the product itself for something else. Liquidity is generated in many ways. I remain somewhat sceptical, however, that the question of needing a dealer or a dealer network to expand or contract liquidity is a public policy issue. It is a fascinating academic issue, but I am not certain that it is a public policy issue.

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General Discussion*

Alexandra Lai began by thanking the discussant for supplying the authors with the caveats that they might have included in the paper. She added that all of the comments and criticisms were valid. Lai explained that this had been a very partial-equilibrium exercise, and it starts with a constrained equilibrium. It does not solve for the optimal overall capital a bank chooses to hold, but assumes that to be a given in the form of capital requirements based on the overall risk of a bank. She said that while there are many ways to generalize this framework, the paper suggests a new way of thinking about the issue of consolidation and capital allocation with respect to the behaviour of dealers and equilibrium in dealership markets.

Richard Lyons said that he considered the spirit of the discussant's comment when banks buy dealers as vertical integration, as opposed to horizontal integration. However, his reading of the paper was more on the horizontal side, and he applied it to the foreign exchange (FX) market. For example, he said, J.P. Morgan and Chase get together and now there is one FX spot trader rather than two, and that is much more of a horizontal integration point.

Lyons went on to say that there is a lot to assume in equation 1,[1] which specifies that the expected cash flow or the expected return is a function of the variance of the returns to that division. He suggested, from a finance perspective, that we teach the CAPM[2] and other models where return is not a function of own variance; it is a function of covariance with the market. So, he continued, if one thinks of this as a proprietary trading desk rather

1. From Bank of Canada Working Paper No. 2002–5. Equation 1 is $E(y_j) = \mu_j(\sigma_j^2), j \in K$, where E is expectations operator; y_j is cashflow of division j; σ_j^2 is variance of cashflow of division j; K is total set of activities that the bank engages in; and μ_j is profit function of division j.
2. Capital asset pricing model.

* Prepared by Nicolas Parent.

than as a market-maker (which he thought the model is general enough to consider), why should one think of return as a function of own variance rather than covariance as the starting point for the model?

Chris D'Souza responded that there are two types of covariance, one across business lines and one within business lines. The authors wanted to do a controlled experiment and focus first on these covariances between business lines, as opposed to within specific business lines, to see what that impact was on market liquidity. Therefore, equation (1) is the positive relationship between returns and risk, but the bank would take into account a correlation across all the different business lines and then decide on capital allocation.

Asani Sarkar suggested that this is basically a two-stage model, where the first stage is the model of capital allocation and the second is the dealership model. He asked if the model is solved as a sub-imperfect equilibrium. In other words, when the capital-allocation decision is taken in the first stage, does it take into account what will happen in the dealership market in the subsequent stage?

Lai replied that these two stages of the model are still a bit disjointed, but that the authors do intend to solve it in that way—first the final stage, then the first stage.

Randall Powley reiterated that if the negative correlation is satisfied and if the reduction of the number of dealers is not too great, there could be a net positive result. He asked—using hypothetical numbers of six banks reduced to three—whether there would still be a positive impact.

Lai responded that anything is possible. Market liquidity can improve if there is a reduction in risk aversion and if the initial pool of dealers is large enough. In this exercise, they had considered reducing the pool of dealers by one. Obviously, she added, one is very small compared to 1,000, but it's large when compared to six. So, the effects of the reduction in the number of dealers and the consequence for risk-sharing in that market would be quite large if one started with five dealers. However, she added, it is possible that the end result is positive if that consolidated dealer had a lot of risk capital behind him.

Allison Holland addressed the idea of horizontal dealer integration. She said that a policy-maker's a priori expectation would be that mergers would reduce the total amount of capital allocated in the market. She thought it comforting that this was demonstrated to not necessarily be the case. However, she had two related thoughts. The first, concerning a point in the Audet, Gravelle, Yang paper, was whether dealer consolidation leads to a more homogeneous set of dealers and what would the impacts of that be for market liquidity. Second, she asked whether a consolidation in the number

of dealers could lead to more implicit collusion, and how could the aspect of collusion be incorporated into the model.

Lai responded to the first point by indicating that when there are two dealers being consolidated, it is not so important that the consolidated dealer have more capital than the sum of those two dealers previously, but simply that he have more capital allocated to him than either of those dealers did initially. In this case, it was not necessary for one plus one to equal two or more. If, for example, there were two initial dealers with one unit of capital each, the new dealer ending up with one-and-a-half units of capital would still have a positive impact on the risk-absorbing capacity of the market.

Responding to the second question regarding whether collusion would become more likely with consolidation, Lai suggested that a dynamic model would be needed to look at that issue, but that it was an interesting point.

D'Souza noted that with respect to homogeneity and heterogeneity, the authors had wanted to show that even though dealers may operate in a specific market and do things in a very similar way, they could be considered heterogeneous because of how the bank itself is structured.

Session 2:
Asset-Price Dynamics

[Title supplied by the cataloguer]

Detecting Shift Contagion in Currency and Bond Markets*

Toni Gravelle, Maral Kichian, and James Morley

It is well known that equity, currency, or banking crises generate substantial real costs for the country in which they occur. Authorities and financial market participants have often been concerned that these crises would spill over or spread, leading to financial system volatility or crises elsewhere in the world. The recent Mexican, Asian, and Russian crises are examples where shocks originating in one country are believed to have spread to other nations and to have resulted in significant costs to the international community.

The transmission of crises from one country to another (or from one market to another) is loosely referred to as contagion, but its definitions are many. One is that contagion occurs when the propagation of shocks is in excess of fundamentals, that is, when shocks have an impact beyond the amount channelled through the usual commercial, financial, and institutional ties between markets. Another, more narrow description is that contagion occurs when shocks spread through herding or irrational behaviour. In contrast, a third and much broader definition refers to contagion as the transmission of shocks through any channels that cause markets to co-vary. There is now a fourth and more precise definition, referred to as "shift contagion," which suggests that contagion occurs when the propagation of shocks during crisis periods increases systematically from that observed during normal times. Given this multiplicity of definitions, it is not surprising to find widely

* The complete version of this paper will be published as a Bank of Canada working paper. The electronic version will be available on the Bank of Canada Web site.

varying opinions as to which crisis events cause (or have caused) contagion. Even when using similar definitions of contagion, empirical studies sometimes conclude differently, especially depending on how they choose to quantify fundamentals.[1]

In this paper, we develop a methodology to statistically detect shift contagion. In particular, we examine whether existing linkages between assets of different countries remain stable during crises or whether they grow stronger. Our approach relies on testing for structural change in the correlation between assets of two markets.

Testing for a shift in how shocks are transmitted across countries has been attempted before, with preliminary results that suggested the existence of contagion. For example, King and Wadhwani (1990) found that the correlation between international equities increased significantly after the October 1987 crash. But Forbes and Rigobon (1999) and others have argued that these conclusions may be misleading, since the simultaneous nature of financial interactions and data heteroscedasticity were not properly accounted for. Taking one or more of these econometric concerns into account, these authors concluded that there is, in fact, little or no contagion. For example, Lomakin and Paiz (1999) found low probabilities of contagion between various country bond markets when they computed the likelihood that a crisis will occur in one country given that it has occurred in another. Forbes and Rigobon (1999) and Rigobon (2001) found little incidence of shift contagion during the Mexican, Asian, and Russian crises in various emerging-country equity and bond markets. Rigobon (1999) found evidence of shift contagion in 15 per cent of the cross-country equity markets he examined during these same crises. Finally, Rigobon (2000) concluded that no shift contagion occurred between 1994 and 1999 in the Brady bond markets of Argentina and Mexico.

These later studies account for certain econometric complications in the data. In particular, the methodology used in Rigobon (2000, 2001) is valid in the presence of both simultaneity bias and data heteroscedasticity. In fact, the method exploits the presence of heteroscedasticity in asset returns, which, it assumes, is due entirely to changes in the variance of the crisis-generating country shock. Under this assumption, if the propagation of shocks between countries is stable, the determinant of the difference between the variance-covariance matrix of returns during normal and crisis periods is zero. The methodology is shown to perform relatively well in

1. Refer to Forbes and Rigobon (2000) and Goldstein, Kaminsky, and Reinhart (2000) for additional details.

Monte Carlo experiments. Nevertheless, the author also points out some drawbacks to the technique.

One is that crisis periods are designated as such, ex post. That is, the beginning and ending dates of crises are determined exogenously. Yet, while there is relative agreement in the literature on the starting date of crises, there is far less of a consensus with respect to ending dates. The associated low-variance periods are generally also determined by rule of thumb. Since test conclusions depend crucially on the choice of the normal and crisis periods, such practices may lead to spurious results. A second drawback is the assumption that increases in the variance of returns during crises are caused entirely by increases in the idiosyncratic shock of one country—the country where the crisis originated. In addition to assuming that the identity of the country generating the crisis is known, according to this hypothesis, a rejection of the null implies either that the propagation mechanism was unstable (i.e., that shift contagion occurred), or that more than one country shock variance increased during the crisis period. Since it is likely that certain common factors will create higher structural uncertainty in a number of economies at the same time (such as unexpected commodity price shocks or policy changes in a large economy), the ambiguity of how to interpret a rejection of the null hypothesis is a serious concern. Furthermore, even if the heteroscedasticity in returns is due to variance changes in the idiosyncratic shock of a single country, there may be more than one candidate for the country of origin.

We propose a methodology for detecting shift contagion that is not subject to the above concerns. First, crisis and low-variance periods are entirely model-determined, instead of being exogenously assigned. Second, the country where the crisis originated needs neither to be known nor included in the system being analyzed. Third, a rejection of the null, in our case, provides unambiguous evidence for shift contagion within the markets examined. Finally, our identification strategy is valid in the presence of variable simultaneity and data heteroscedasticity.

We make use of a bivariate unobserved factor model for asset returns. The asset returns are assumed to be correlated, which is modelled by having correlated disturbance terms for the two processes. In turn, these disturbance terms are decomposed into common and idiosyncratic structural shocks. We allow for independent regime switching in the variance of the common and idiosyncratic shocks, which allows us to develop a test for shift contagion. This test assumes that in the absence of shift contagion (the null), common large shocks do not change the propagation mechanism of these shocks.

Our methodology is applied to bond markets of four emerging countries (Argentina, Mexico, Brazil, and Venezuela) and currency markets of seven developed countries (Canada, Australia, Japan, Germany, Sweden, Norway, and Switzerland). Contagion has traditionally been examined in emerging countries, since assets in these markets are particularly volatile and crises occur frequently. Our bond market data are therefore included for comparison with previous studies, such as Rigobon (2000, 2001).[2] We also examine currency markets of developed countries. Given the greater economic transparency, efficiency, and integration in these countries, assets are less volatile than in emerging markets. Therefore, less attention has been paid to structural change in the co-movement of assets in these markets. Indeed, a priori, it should be more difficult to detect shift contagion in these cases.

Interestingly, our results do reveal evidence of shift contagion in some of these currency markets. More specifically, in some of the developed currency markets, there is evidence to suggest that propagation of common shocks is stronger during turbulent periods. In particular, the results indicate that the null of no shift contagion is rejected at the 10 per cent level for the following country pairs: Sweden-Germany, Sweden-Japan, Sweden-Switzerland, Switzerland-Germany, Norway-Australia, and Norway-Japan. Our results also support Rigobon's (2000) findings, since we also find no evidence of shift contagion among the Latin American bond markets examined. That is, the empirical results suggest that shocks are transmitted via long-term linkages between these countries.

Our findings should be regarded as a first step in addressing the issue of how policy-makers should react when observing periods of heightened volatility and increased cross-market correlations. One objective of the contagion literature is to ascertain how countries can reduce their vulnerability to external shocks. In this vein, it is important to understand whether a shock is transmitted across markets via channels that appear only during turbulent periods (crisis-contingent channels), or whether these shocks are transmitted via channels or interlinkages that exist in all states of the world. The existence of shift contagion would suggest that shocks are propagated via crisis-contingent channels. The effectiveness of short-term or temporary policy measures aimed at reducing a market's vulnerability to contagion will depend on whether or not contagion occurred as a result of the transmission of shocks through pre-existing long-term linkages or through crisis-contingent channels.

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2. Strictly speaking, changes in the co-movement of assets are detected whether they occur as a result of a crisis, or because of some other high-variance news event.

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Discussion

Shafiq K. Ebrahim

Toni Gravelle, Maral Kichian, and James Morley have written a very interesting paper that seeks to improve our understanding of asset-market linkages and dynamics during financial crises. The authors contribute to the burgeoning literature on contagion by developing a bivariate regime-switching model to detect whether the relationship between two asset markets changes during a crisis. This model is applied to weekly data from seven developed foreign exchange markets and four Latin American bond markets. Gravelle, Kichian, and Morley observe some evidence of contagion between developed currency markets, but none between emerging bond markets. From a public policy perspective, these findings suggest that shocks between Latin American bond markets are transmitted through long-term linkages, and short-run policies would likely not mitigate their adverse effects.

The econometric framework outlined in the paper has many attractive features. It allows normal and crisis regimes to be determined endogenously rather than being assigned exogenously, as is common in the literature. In addition, the regime-switching model is flexible enough to allow common and idiosyncratic shocks to the two asset markets to be in separate volatility regimes in any period. The model also performs well insofar as it is able to accurately identify from the data past turbulent periods, such as the Mexican peso crisis of 1994, the Asian crisis of 1997, and the Russian/Long-Term Capital Management crisis of 1998.

I have a few comments about this paper. The first concerns the authors' tests for the presence of shift contagion. They define shift contagion as occurring "when the propagation of shocks during crisis periods increases systematically from that observed during normal times" (see p. 85). This definition is similar to the one offered by Forbes and Rigobon (2000), who

describe shift contagion as "a significant increase in cross-market linkages after a shock to one country or region." Underlying both definitions is the notion that linkages between markets must have increased for contagion to have occurred. How can we test whether cross-market linkages have changed?

Consider the following simple model based on Forbes and Rigobon (2000). Let two asset returns, x_t and y_t, be described as follows:

$$y_t = \beta x_t + \gamma z_t + \varepsilon_t,$$

$$x_t = \alpha y_t + z_t + \eta_t,$$

$$E(\eta_t' \varepsilon_t) = 0, E(z_t' \varepsilon_t) = 0, E(z_t' \eta_t) = 0,$$

$$E(\eta_t' \eta_t) = \sigma_{\eta_t}^2, E(\varepsilon_t' \varepsilon_t) = \sigma_{\varepsilon_t}^2, E(z_t' z_t) = \sigma_{z_t}^2,$$

where z_t is a common shock, and ε_t and η_t are idiosyncratic and independent shocks. According to this model, shocks are transmitted from the market x_t to the market y_t through the parameter β, and from y_t to x_t through the parameter α. The common shock has different effects on the two markets (with the coefficient on z_t in market x_t normalized to one), and is independent of the idiosyncratic shocks.

Solving for the reduced-form equations, we have:

$$y_t = \frac{1}{1-\alpha\beta}[(\gamma+\beta)z_t + \beta\eta_t + \varepsilon_t],$$

$$x_t = \frac{1}{1-\alpha\beta}[(1+\alpha\gamma)z_t + \eta_t + \alpha\varepsilon_t].$$

The existence of shift contagion could be ascertained by testing whether α and β are different between crises and normal periods. It is possible to view the framework presented by Gravelle, Kichian, and Morley as one in which $\alpha = 0$ and $\beta = 0$ in all states of the world, yielding the following:

$$y_t = \gamma z_t + \varepsilon_t,$$

$$x_t = z_t + \eta_t.$$

Consequently, the paper effectively tests whether there is a change in the magnitude by which the common shock (through γ) influences asset returns during crises compared with normal periods. In this model, however, changes in exogenous common shocks do not affect cross-market linkages

and therefore do not generate contagion. For example, suppose that two countries are exporters of a commodity whose world price decreases sharply. Then, asset prices in the two countries may both decrease simultaneously, and correlations between the markets may increase. However, the propagation mechanism of shocks *between* the two markets would not have changed, and so the exogenous commodity price shock would not generate shift contagion.

It seems to me that to properly test for the existence of shift contagion using the authors' framework, it would be necessary to separate the effects of other market shocks from those of common shocks in the equations describing asset returns. This would admittedly be a difficult econometric problem to solve, and would likely require making a number of simplifying assumptions.

My second comment concerns the econometric methodology in the paper. To better assess the specification of the econometric model, I think that it would be helpful if the authors reported the results of residual diagnostic tests. In particular, it would be interesting to see how well the model captures the ARCH (autoregressive conditional heteroscedasticity) effects in asset returns documented in the paper.

Based on their analysis, Gravelle, Kichian, and Morley conclude that shift contagion does occur between developed currency markets. While this finding may be accurate from a statistical perspective, it would be interesting to determine whether the contagion is economically significant. How strong is the contagion? I feel that the paper would benefit from the inclusion of these additional data.

Finally, I have a few suggestions for extensions to the paper. The authors find no evidence of contagion between emerging bond markets using their model, but does this observation also hold for other emerging financial markets? It would be especially interesting to study emerging currency markets in light of the financial crises that the world has witnessed in the past decade.

In designing their regime-switching model, the authors use unconditional probabilities to model the transitions between high- and low-volatility regimes. In adopting this somewhat restrictive structure, the authors are unable to capture persistence in the data from the likelihood of an asset remaining in the same volatility regime from one period to the next. Tackling the estimation of the more general model with conditional probabilities would undoubtedly be a challenge, but the resulting framework should enable us to gain deeper insights into the nature of asset-market dynamics during financial crises.

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General Discussion*

James Morley thanked Shafiq Ebrahim for his comments. He added that many of them were quite useful, particularly in terms of what the authors had wanted to do for diagnostic tests. Having conditional transitional probabilities is a particularly important extension in making the modelling of the crisis regime richer, he said, and that is something that they would want to do. He noted that these models—even with a fairly simple specification—become complicated. The authors had sought to be transparent in the model by keeping it simple. Morley thought that the Forbes-Rigobon distinction between common shocks and structural linkages was sensible in terms of dynamics, and that dynamics are important to model with these techniques. But one of the ways the authors simplified their model was in terms of dynamics: the shocks did not show up across different places and across time. However, he emphasized that no observational distinction really exists between a common shock and a shock that transmits immediately from country A to country B. Thus, he said, although the model ended up being simpler than the Forbes-Rigobon model, the Gravelle, Kichian, and Morley model can be considered a special case. He added that another useful extension for the paper would be to look at markets where the dynamics could be examined more carefully, and that would give them more power to detect this kind of change in the structural linkages across countries and time.

Toni Gravelle said that a footnote indicating that the coefficients are available upon request could have been included. He mentioned that there are 14 per country pairs or country-market pairs, and that would have

* Prepared by Des Mc Manus.

implied a large number of tables. He added that it would be a good idea to provide a sample of the coefficients.

Mark Zelmer suggested that most of the contagion being found seems to involve the European currencies. He asked to what extent the results were being driven by the breakdown of the European system in 1992, and therefore to what extent are the results being driven by one event as opposed to being more robust.

Morley answered that the authors had not done that robustness check. He added that it was a statistically significant result and that there were other common shocks for those countries than just the exchange rate mechanism (ERM) crisis. He said that from a statistical point of view—and this may help answer some of the other questions—they were simplifying. He stressed that there are common shocks and that they have a certain type of propagation. And they are allowed to have a different propagation in another regime. Thus, he noted, the authors were really thinking of only two different types of shocks. The real world, he added, is a lot more complicated, where various shocks—commodity prices, U.S. monetary policy shocks—all have different transmission mechanisms. But, he stressed that if it really were just the ERM crisis, the methodology should pick that up as a one-time spike. He pointed out that regime-switching models sometimes, unfortunately, tend to fit a single data point. But, that is not what they had found. They found that there were repeated common shocks with sometimes clearly different transmissions than with the shift contagion.

Richard Lyons said that he had enjoyed the paper very much and that he considered the issue an important one. He thought that if he estimated the model at the monthly frequency, and if he had enough data (so the test had power), he suspected that in the currency markets one might still find what could be called shift contagion semantically, but one wouldn't associate it with crises. It would be a lower-frequency phenomenon. Lyons had in mind a paper written by Charles Engel and Jim Hamilton (1990), which suggested that long swings in the dollar would effectively show up as common shocks if the identification scheme is looking at the ratios of various common shocks to idiosyncratic shocks. If one sees a long swing in the dollar against many other currency pairs, the data are going to indicate many common shocks in a row and a model might suggest shift contagion. Thus, while similar results might be found at lower frequencies, one would conceptualize it very differently.

Morley thought that the advantage of independent switching is that it really does limit the methodology to picking up just one-time crisis events rather than longer-term structural changes in the data or longer swings in the dollar. He added that it might be useful to make the regime-switching model

a little more complicated, but one has to be wary that in doing so one will pick up other non-linearities in the data and distract oneself from the question at hand, which is: do crises have shift contagion?

David Longworth mentioned that one of the slides indicated that there are many different kinds of common shocks, and one might think of some of them as being fundamentals, for example, U.S. interest rate movements or Canadian and Australian commodity price movements. And, he added, there are things that would be difficult to relate to economic events that preceded the shock. He asked how far one can go with this methodology without returning to examine the pairs where there is no shift contagion and trying to dig a little deeper into those spikes of the common shocks. He said that there would appear to be no reason to believe that the coefficients would shift equally—or not—between U.S. interest rate movements and changes in commodity prices and things that were disturbing financial markets for unknown reasons.

Morley responded that one would want to look into each case where one finds shift contagion, examine the common shocks, and try to identify them. He added that the authors had done a bit of that in the paper to identify them with the events that were occurring at the time, to try to determine whether they are the types of shocks that they had thought were fundamentals or whether they were something else.

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Price Discovery in a Market Under Stress: The U.S. Treasury Market in Autumn 1998*

Craig H. Furfine and Eli M. Remolona

We analyze price discovery in the interdealer market for U.S. Treasury securities during stressful days in autumn 1998. Long-Term Capital Management (LTCM) had found itself with losing short positions in on-the-run Treasury securities, and yields on these securities were particularly volatile. Trading activity was intense, with durations between transactions shorter than usual.

Using tick-by-tick data on interdealer transactions in the on-the-run two-year, five-year, and ten-year notes, we find that during such periods of intense trading, the effect of trade flows on price movements became stronger, a phenomenon Dufour and Engle (2000) have documented for the stock market. We also find that during times of stress, depth was asymmetric between buy and sell sides, and this asymmetry affected the importance of trade flows for price movements. Moreover, market-makers seemed exceptionally reluctant to take risks. After identifying ten particularly stressful days for each on-the-run security, we find that the effect of trade flows on prices was significantly stronger on these days, even after accounting for the intensity of trading and the asymmetry in depth.

In the market-microstructure literature, order flow affects prices because it conveys private information regarding the value of the underlying asset. In Glosten and Milgrom (1985), for example, market-makers set a positive bid-ask spread as compensation for trades made with counterparties with superior information. As a sequence of sell orders arrive, market-makers lower bid prices, incorporating the probability that the order flow implies that better-informed investors believe the previous price was too high. In a very general empirical framework, Hasbrouck (1991) documents the

* For complete paper, see conference draft version.

positive relationship between order flow and price changes, using a sample of eighty New York Stock Exchange and American Stock Exchange stocks.

The literature has since been extended to determine *when* order flow is expected to have the greatest impact on prices. In Admati and Pfleiderer (1988), discretionary liquidity traders try to avoid losing money to the better informed by clustering their trading at around the same time. Thus, the observation of multiple transactions occurring together suggests the presence of predominantly uninformed traders. Order flow would then not be expected to have a large impact on prices. Contrast this intuition with that modelled by Easley and O'Hara (1992). In their model, they explicitly allow for the possibility that no new information exists. As a result, an increase in trading volume indicates that news has occurred and, therefore, order flow is more informative when transactions are occurring rapidly.

The empirical evidence on when order flow is important has provided mixed results. In foreign exchange markets, Lyons (1996) documents that trades are less informative if they occur when transaction intensity is high, a finding consistent with the theoretical result of Admati and Pfleiderer. Lyons describes it as hot-potato trading, whereby foreign exchange dealers rapidly and repeatedly lay off unwanted inventory in response to an initial potentially informed trade. By contrast, in equity markets, Dufour and Engle (2000) explicitly incorporate the role of inter-transaction time in the empirical framework of Hasbrouck (1991) and find that when equity markets are most active, i.e., inter-transaction times are short, the impact of order flow on prices is enhanced. Thus, the empirical literature has found opposite relationships between inter-transaction times and the price impact of trading, depending on the market being examined.

Our paper makes two contributions to the understanding of when order flow exerts a stronger influence on prices. First, we replicate the analysis of Dufour and Engle with transaction-level data on the U.S. Treasury market. Thus, we learn whether the busy periods of Treasury market trading are characterized more by the hot-potato view or by more information-based trading. Second, and perhaps more significantly, we examine whether or not the price impact of trading changes during a period of unusual financial stress. We closely examine the market during autumn of 1998, a particularly turbulent time for the market.

"The Johnson Report" (see Committee on the Global Financial System 1999) suggests three reasons why the Treasury market on certain days in autumn 1998 may be considered to have been fundamentally different from other days. First, some dealers became more reluctant to make markets during this period. Many dealers had already incurred grievous trading losses in August. Some of them were also counterparties of LTCM and were

concerned about the possibility of a default of the hedge fund. Thus, dealers began to withdraw from risk-taking, including reducing their market-making activity. Second, the market tended to be asymmetric. In particular, depth was reduced for trades perceived as being in the same direction as LTCM's unwinding of positions. Moreover, market participants were seen as trading on the anticipation that LTCM might be forced to close out its positions. Third, there was an unusual degree of uncertainty about what was going on. The Johnson Report, for example, states, "In this situation of great uncertainty, rumours were rife and often fed upon themselves" (p. 15).

To examine whether there were fundamental changes to the U.S. Treasury market in autumn of 1998, we use data from GovPX. This data set consolidates each tick (e.g., change in quoted spread, depth, or transaction increment) from five of six interdealer brokers, accounting for perhaps half of all transactions in the market. The data include the best bid and offer quotes for each security, the depths for both ask and bid quotes, the price and size of each trade, and an indicator for whether the trade was buyer- or seller-initiated.

Summary statistics indicate two notable changes in Treasury market activity during the crisis of 1998. First, trading volume in the U.S. Treasury market increased dramatically. The implication of higher volume is that average inter-transaction times fell accordingly. Second, the typical quoted depth in the market changed in two ways. Depth size declined, consistent with a period of greater uncertainty. In addition, the decline in depth during the crisis period was more acute on the ask side of the market. This asymmetry in depth is particularly striking, because we presume that during normal times the interdealer market tends to be deeper on the ask side, since dealers would be expected to be in the process on unwinding long positions in on-the-run securities in preparation for the next auction. Put another way, market participants during stressful times in 1998 became less willing to commit to being ready to sell a given quantity at quoted prices. This is consistent with less liquidity in the same direction of a close-out of an LTCM-type position.

We then employ a more formal empirical test of whether the dynamics of price adjustment changed during the crisis period. Our framework builds upon the work of Hasbrouck (1991), Dufour and Engle (2000), and Cohen and Shin (2002). In particular, it explicitly allows for different market dynamics during the crisis period of 1998, as might be suggested by the time-series plots presented in Fleming (2001). We follow Dufour and Engle's approach of explicitly incorporating inter-transaction time into Hasbrouck's vector-autoregression model of prices and trades. In addition, we explore the effects of stress over and above that of trading intensity. We

examine these effects in two ways, by measuring the effect of asymmetric depth and by distinguishing the most stressful days from other days. We also conduct analysis on the two-, five-, and ten-year on-the-run security.

In general, the dynamics of trading in the Treasury market are much like those found in other markets. In particular, returns are negatively autocorrelated, trades are positively autocorrelated, and order flow moves prices in the expected direction. During periods of intense trading, the effect of trade flows on price movements in the Treasury securities market becomes stronger, the phenomenon Dufour and Engle (2000) have documented for the stock market. Using, for example, our results for the on-the-run five-year Treasury note, we can quantify the relationship between the time between trades and the price impact of a trade. During busy times, defined as the 10th percentile in the inter-transaction time distribution (2 seconds), 10 trades in the same direction are expected to move prices by 2.7 basis points. Ten trades arriving at the median inter-transaction time (32 seconds) would move prices by only 2.0 basis points.

Times of stress do seem to impose their own special dynamics on the market. First, we find evidence on the importance of asymmetric depth on the price impact of a trade. Trades where depth is shallower had significantly more impact on prices than trades on the opposite side. Second, the crisis period of 1998 witnessed a dramatic increase in the price impact of a given trade. Even after controlling for the compression of inter-transaction times and for asymmetric depth, trading during the crisis moved prices much more than trading during the more normal times of 1998. For instance, on a stressful day, 10 trades of the same sign would have led to a 3.9 basis points price move in the five-year on-the-run Treasury note, even if these transactions arrive at the median inter-transaction time.

Our results suggest that in the U.S. Treasury market, busy times are times of more informative trading. Furthermore, asymmetry in depth matters, since trades in the direction of lower depth move prices more than trades in the opposite direction. Finally, market stress reduces liquidity, as measured by the price impact of trading. Even after controlling for an increased rate of trading, the price impact of trading during a crisis period is higher than during normal times.

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Discussion

Asani Sarkar

There has been a resurgence of research interest in issues of crisis, contagion, and commonality in liquidity. The paper by Furfine and Remolona is a welcome addition to this literature. Fleming (2001) had shown that price impact and trading activity are higher during crisis periods. Furfine and Remolona show that price impact is higher, even after accounting for trading activity.

In the paper, the proxy for trading intensity activity is the time between trades (Dufour and Engle 2000). Furfine and Remolona state that trades during crisis periods may reflect far more information above and beyond the information being conveyed by their increased rate of arrival. It is not clear, however, what kind of information is conveyed by rate of arrival of trades in the government bond markets.

Information in Stock and Bond Markets

The nature of information conveyed by trade arrival is clear in the context of equity markets. Dufour and Engle (p. 2469) apply their model to equity markets, and they state: "informed traders may choose to break up large volume trades, thereby generating a large number of informationally based trades. . . . Therefore, trading intensity, which results in short and long durations between trades, may provide information to market participants."

For government bond markets, Furfine and Remolona find that trades are positively autocorrelated. They interpret this result to mean that informed traders break up trades. But are there informed traders in Treasury bonds? An alternative interpretation lies in an institutional feature of government

bond markets: there is quantity negotiation but no price negotiation in Treasuries. Thus, large trades have to be broken up, irrespective of trader intentions.

It is likely that the nature of information in bond markets is more similar to foreign exchange than to equity markets. Order flow is informative, but traders do not have private information about asset values. Order flow may move trades because it could be informative of dealers' inventory positions or market demand conditions. So why should time between trades be relevant for bond markets? Perhaps the trade duration is related to changes in dealer inventory. In any case, this issue needs further exploration.

Empirical Design

The main issue here is the selection of the crisis period. There is no widely accepted method, but the crisis period should not be selected based on volatility. The authors use the change in swap spreads, and the change is likely to be correlated with volatility. I prefer selection criteria based on exogenous variables. A simple alternative is to use the fact that there is a degree of consensus as to when the crisis occurred in calendar time. Thus, the authors could use a longer sample, say all of 1998, then consider the period July-December 1998 as the crisis period (Bank for International Settlements 1999). This would include both volatile and non-volatile days and would be a better proxy for crisis. (The paper currently uses May-December 1998 as the sample period, so there is essentially no "normal" period in the sample.)

I am also concerned whether the dummies, as they are defined, are picking up a crisis effect or something else. To examine this issue, the authors should study days with high and low swap-spread changes during both normal and crisis periods—is there a difference? Similar remarks apply to the dummy for asymmetric bids—are these unique to crisis periods? More generally, the dummy-variable approach is sensitive to model misspecification (specific functional forms, lag structure). It would be useful to try alternative ways of introducing the trade duration T; instead of log(T), the authors may consider using time-interval dummies that are not sensitive to specific functional forms.

Other Comments

There are strong day-of-the-week effects in bond markets. Since there are only ten crisis days, it is worth checking whether such calendar effects are driving the results.

How sensitive are the results to the omission of slow trading days? The claim in the paper is that such days are "atypical," but then so are crisis days.

Clearly, trade time is not exogenous (Dufour and Engle). This problem is particularly acute in the application here. This is difficult, but Dufour and Engle suggest some diagnostics.

Overall, Furfine and Remolona have written an interesting paper on an important topic. I look forward to a revised version, incorporating a discussion of information flows in the Treasury bond markets and a robust empirical design.

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General Discussion*

Eli Remolona thanked Asani Sarkar for his comments. In response to Sarkar's question regarding what information was allowing trades to matter on prices, he said that they had in mind order-flow information. During the LTCM episode, some dealers presumably knew more about what LTCM was trying to do than others, because LTCM was dealing with some dealers and not with others.

He said that the authors had looked at different ways of defining stress days. They could have estimated the benchmark equations every day—with hundreds of transactions each day, they had enough data. They could have estimated the benchmarks and looked at which days had the most effect to see whether they made sense as stress days.

Sarkar had wondered how unusual the asymmetries were. Remolona felt that this was a very good point. He said that the authors had not done that work, but that they would do so.

Remolona mentioned that they had experimented with the functional forms. Although they had better results with other functional forms, they decided to present the ones that are more comparable with Dufour and Engle. They tried the square root of time, for example, dividing by it, rather than multiplying by it. He said that there are some trades that are zero (time) between trades; they therefore gave it one second if it was zero so that a finite square root term could be used.

* Prepared by Mark Reesor.

Remolona said that they would look at the day-of-the-week effects. He added that in a sense it was the same as excluding atypically slow days. They had done work on this market before and had a sense of which days were bad and which were good.

He admitted that trading time was endogenous and that the authors did not know what to do about it. He said that perhaps they would consult some more with Sarkar.

Zhiwei Zhang had two comments. The first concerned the duration variable or the trade time in the bivariate vector autoregression (VAR). He suggested that it might be valuable to estimate a three-variable VAR instead of a two-variable VAR just to make it endogenous in that way. He thought that Engle and Dufour used their autoregressive conditional duration (ACD) model to have a separate model to describe the duration dynamics. He added that it might be challenging in terms of the technical difficulties, but the authors might also be able to tell an interesting story with three variables.

Zhang's other comment touched on the coefficients. He suggested that it might be useful to make them time-varying, for example, to make them a function of some measure of the intensity of crisis or of just how stressful it is in the market situation.

Portfolio Balance, Price Impact, and Secret Intervention*

Martin D.D. Evans and Richard K. Lyons

Portfolio-balance models occupy an important place within exchange rate economics. They are still used, for example, as a basis for why central bank intervention in foreign exchange markets can be effective even when sterilized (i.e., even when intervention has no effect on interest rates or money supplies). Empirical evidence supporting these models is scant, however. This paper tests the portfolio-balance model in a new, more powerful way and finds it strongly supported.

Past work on portfolio balance across assets denominated in different currencies falls into two groups: (i) tests using measures of asset supplies; and (ii) tests using measures of central bank asset demand. Here, we address the demand side, but we examine demand by the public broadly, rather than focusing on demand only by central banks. Under floating rates, changing public demand has no direct effect on interest rates, current or future. This provides an opportunity to test for whether price effects play a role in achieving portfolio balance. Because data on public trades became available only recently (with the advent of electronic trading), this strategy is feasible for the first time.

The discriminating power of our approach arises from avoiding difficulties inherent in past approaches. The asset-supply approach, for example, has low power because measuring supplies and their variation over time is

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* The complete version of this paper can be found at:
< www.haas.berkeley.edu/~lyons/wp.html >.
Also published as National Bureau of Economic Research Working Paper No. 8356.

notoriously difficult. First, one must determine which measure of supply is the most appropriate. (There is considerable debate in the literature about this issue.) Then, for any given measure, the consistency of data across countries is a concern. Finally, these data are available only at lower frequencies (e.g., quarterly or monthly) and are rather slow-moving, making it difficult to separate the effects of changing supply from the many other forces moving exchange rates.

The central bank demand approach—an "event study" approach—may also have limited statistical power because central bank trades in major markets are relatively few and are small relative to public trading. For example, the size of the average U.S. intervention in the 1980s was only about $200 million, or roughly one-tenth of one per cent of the daily spot volume in either of the two largest markets. (In the 1990s, U.S. intervention was more infrequent but larger, typically in the $300 million to $1.5 billion range; at the same time, market volume was higher too.) Though the central bank demand approach is more successful than the supply approach in finding portfolio-balance effects, results are not exclusively positive and the extent to which these event studies pertain to portfolio effects more broadly is not clear.

The "micro portfolio-balance model" we develop embeds features more familiar to models from a sub-field of finance called microstructure. For example, the model clarifies the role played by a variable called "order flow" in conveying information about shifts in traders' asset demands. (The concept of order flow comes from microstructure finance and refers to *signed* volume. For example, a sale of 10 units by a trader acting on a dealer's quotes is order flow of –10.) Beyond clarification of the basic role played by order flow, two analytical results in particular are important guideposts for our empirical analysis: (i) order flow's effect on price is persistent (even when beliefs about future interest rates are held constant); and (ii) when central bank trades are sterilized, conducted secretly, and convey no policy signal, then the price impact of these trades is indistinguishable from that of public trades. This latter result links our analysis directly to intervention operations of this type.

With the advent of electronic trading and the data it provides, we have a powerful means of testing our portfolio-balance model. We establish three main results. First, testable implications of our model are borne out: we find strong evidence of price effects from portfolio balance. Thus, the portfolio-balance approach—with its rich past, but lack of recent attention—appears to warrant some fresh consideration. We consider this "resurrection" of the portfolio-balance approach the paper's most substantive contribution,

versus, for example, the paper's more narrow implications for intervention policy.

Our second main result is the precise estimate we provide of the immediate price impact of trades: about 0.5 per cent per $1 billion (of which about 80 per cent persists indefinitely). With gross flows in the largest spot markets at about $300 billion per day, this level of price impact is potentially quite important. An immediate example of this fact's value is its ability to help us understand why portfolio-balance effects from sterilized intervention are so hard to detect: the average-sized intervention of $200 million in the 1980s translates into an exchange rate movement of only 0.10 per cent, an amount easily swamped by movements due to other factors.

Our third result speaks to intervention policy. It clarifies how the unconditional price impact of 0.5 per cent per $1 billion varies with the state of the market. The most important state variable for the size of this price impact is the flow of macroeconomic announcements. (It may be, for example, that order flow is the variable that market participants use to resolve uncertainty about how these announcements are interpreted.) Whatever the reason, our estimates imply that trades have the most price impact when the flow of macroeconomic news is strong.

When applying our price-impact results to intervention policy, it is important to keep in mind that intervention in practice rarely takes the form we are examining in our paper (i.e., all the trades in our model are anonymous). Our analysis simply cannot address intervention that is conducted in any way other than anonymously. We realize that there is something of a consensus among economists that transparency (i.e., non-anonymous trading) is good when it comes to intervention. Our paper is an attempt to shed light on the other pole of the transparency spectrum—where intervention trades look exactly like anonymous private trades. This is a well-posed question, even if implementation of secret intervention is more challenging. If the central bank can trade anonymously, then one should expect its trades to match the average anonymous-trade price impact in the market. This conclusion does not require one to take a position on what is driving the rest of that order flow in the market.

Our paper's theoretical model provides an additional insight into why past sterilized intervention has often been ineffective. In our model, if order flow is expected to be reversed, it will not have much price impact. When customer position changes are permanent, order-flow effects on price have lasting portfolio-balance effects. In practice, after intervening, many (most?) central banks engage in systematic rebalancing of their currency positions (i.e., they tend to return to their pre-intervention portfolio composition).

This is problematic from a theoretical perspective if the objective is lasting exchange rate effects.

Finally, we offer some thoughts on future application of our trading-theoretic approach to intervention. Market data now coming available allow for precise tracking of how the market absorbs actual central bank trades and any information in them. Central banks with precise knowledge of their own trades—announcements, timing, stealth level, etc.—can estimate the impact of these various "parameter" settings. Consider the fact that the type of data used in recent work includes the order books of electronic interdealer brokers. A central bank with these data, over a sufficiently large number of intervention trades, can learn exactly how the "book" is affected, including the process of price adjustment, liquidity provision on both sides, and transaction activity. The situation (process) brings to mind a doctor who has a patient ingest blue dye to determine how it passes through the system. The whole process becomes transparent. Such is the future of empirical work on this topic.

Discussion

Chris D'Souza

In their paper, Evans and Lyons develop a multi-stage model of the foreign exchange market. Although the focus is different, the model is similar in many respects to the simultaneous interdealer trading models presented in papers by Lyons (1997) and Evans and Lyons (2002). While speculative motives for interdealer trading are analyzed in their previous work, the authors choose here to focus on the risk-sharing decisions of dealers and the public in the foreign exchange market. The initial catalyst for trading in the model is an exogenous portfolio shift by customers in terms of their foreign exchange holdings. Since dealers and the public are risk-averse, they demand a risk premium to absorb the undesired position of their counterparties. The connection between the model presented by Evans and Lyons and the portfolio-balance model in its previous form (Branson and Henderson 1985) is now clear: the central assumption of the portfolio-balance models is the imperfect substitutability of assets.

The model presented by Evans and Lyons allows for asymmetric information among dealers in the foreign exchange market. Specifically, each dealer has private information about his or her own customers' orders. Trade transparency is also enhanced with observations of order flow, or the net foreign exchange imbalance in the market. Although transmitted in reality via interdealer brokers, this addition to the model conveys a dealer's "feel for the market." The model is able to clarify the role played by order flow in conveying information about portfolio shifts that is critical to dealers making decisions about risk-sharing. Evans and Lyons are able to closely replicate many of the features of the market in their model, an essential feature in the market microstructure literature.

The model is complicated by the multiple rounds of trading among dealers. In every round, each dealer must update his or her priors about the

magnitude of the portfolio shift before submitting a trade order. The paper focuses on the risk premium (or price-level adjustment) that dealers demand in order to adjust their inventory position as a result of the portfolio shift. The paper also examines the compensation that the public must be awarded to take on this market imbalance when dealers end each day with a zero net position.

In their empirical analysis, the authors attempt to measure both the transitory risk premium demanded by individual dealers from the temporary position they hold, and the persistent price effect resulting from the risk premium demanded by the public. This persistent effect exists once risk-sharing among the wider market is complete. The results are then used to characterize the effects of hypothetical sterilized (non-policy-related) secret intervention operations by the monetary authority. Transaction-level trade data for the DM/US$ over the period 1 May to 31 August 1996, collected from the Reuters Dealing 2000–1 system, are employed in the exercise. While the size of each transaction is not known, the trade initiator is known, so that order flow is measured as the sum of buyer-initiated purchases less seller-initiated sales.

The authors find strong support for the portfolio-balance approach. Specifically, there is a 0.44 per cent change in the DM/US$ exchange rate for a $1 billion trade. More importantly, 83 per cent of this effect persists indefinitely. This estimate is then used by Evans and Lyons to determine the impact of sterilized secret intervention by the monetary authority. Non-parametric kernel estimation is used to determine whether the price impact of trades depends on the state of the market. One result suggests that when the number of macroeconomic announcements is large, the effect on prices from order flow is large.

The order-flow view of the exchange rate has allowed macroeconomists to look at an alternative and promising view of the foreign exchange market that explicitly accounts for the microeconomic features of the market. In Evans and Lyons (2002), 60 per cent of the variability in the DM/US$ exchange rate can be accounted for by order flow. In D'Souza (2002), 35 to 40 per cent of the variability in the Can$/US$ is accounted for by order flow. Macro models rarely account for more than 10 per cent of the variation in exchange rates. The most interesting feature of this paper is the characterization of the model in the light of the portfolio-balance approach. The model clearly demonstrates that a large proportion of the variability in exchange rates is a resu't of portfolio shifts.

A powerful feature of market microstructure models is their ability to accurately reflect the institutional features of the market. While the paper has many positive aspects, several important assumptions of the paper need

to be further examined. The first is that if the central bank intervenes secretly, and in a sterilized manner, with no implicit monetary policy signal, the estimates obtained in the paper from interdealer trades can be used as a proxy in determining the impact of the central bank intervention operations. The authors point out that this exercise would be more informative if public trades were available. But of greater concern is the fact that the authors make no distinction between public orders and central bank orders. They have assumed that central bank trades, like public trades, are a result of an exogenous portfolio shift in the holdings of the monetary authority. The problem with this assumption is that the term "intervention" necessitates an objective function for the intervening agent. Surprisingly, the authors propose that policy-makers may intervene to ensure liquid or orderly markets. Altering the technical outlook to avoid the emergence of extrapolative expectations, or adding liquidity in periods of added uncertainty when currency markets "gap," are two instances where the monetary authority intervenes to ensure orderly markets. If these are the types of examples that the authors have in mind, then the monetary authority does indeed have an objective function, and an inconsistency exists within the model.

If the central bank intervenes when markets are believed to be disorderly, even though intervention is secret, dealers will, over time, estimate a non-zero prior that an incoming trade has originated from the central bank. Possible opportunities for speculation by dealers who have received the trade will arise and, as such, prices may not only reflect a risk premium, but speculative strategies based on a game played between the central bank and dealers, and subsequently, between dealers and other dealers.

The second point that needs to be addressed is that the authors assume that public trades do not convey payoff-relevant information and, therefore, any persistent price effects are a result of portfolio shifts. Alternatively, persistent price movements may not only reflect the risk premium demanded by the public as a result of a portfolio shift, but information in trades about macroeconomic fundamentals. This is not to say, however, that traders knowingly have this information at hand (e.g., insider trade information). What I have in mind is that public trades may implicitly summarize the competitiveness of the economy via international trade and investment flows (mergers and acquisitions). Furthermore, once aggregated, net order flow may convey this fundamental information to a wider market. Hasbrouck (1991, 1995) finds that in equity (and derivative) markets there is private information in trades. Identifying the two types of persistent effects in the Evans and Lyons study may be possible only with a long enough data set.

My final concern relates to the state dependency results of the paper. It suggests that the impact of trade orders on prices was not significantly affected by price volatility, which the authors argue suggests that intervention would affect foreign exchange markets in similar ways whether orderly or disorderly. Is this not counterintuitive? The price-level impact or the risk premium should adjust with increases in the standard deviation of prices. Does the insignificance of the result have something to do with the length of the data sample, a period where disorderly markets in the DM/US$ were not a concern?

Overall, the model and results of the paper are new and innovative. They make a definite contribution to the exchange rate literature by exploring the impact of risk-sharing by dealers and the public on the dynamics of short-term exchange rates. The paper is able to quantify the temporary and permanent impact of customer trades on exchange rate. Leaving out the application of the model and its estimates to exchange rate intervention will not reduce the importance of the paper to the literature.

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General Discussion*

Richard Lyons opened the discussion by saying that the comments on the need to include institutional realism in their model were relevant. However, he noted, the model did capture some important institutional realities, namely, that dealers do not carry overnight positions, and the interdealer market is where the process of price discovery takes place. He admitted that it is possible that price discovery also takes place in the direct (as opposed to brokered) interdealer market, but they did not have data on this and modelled what they could within the limits of their data and a parsimonious model specification.

Regarding the need to include a central bank's objective function, Lyons emphasized that the central bank's actions come as a surprise to the market, and this surprise causes a price adjustment. Having a predictable objective function won't change the price effect, only the timing of the price adjustment.

As to whether prices are adjusting to movements in fundamental information or risk premiums (portfolio-balance effects), Lyons argued that the order flow is itself information-relevant to the market, and that the traditional definition of "fundamentals" (macroeconomic data releases only) is too narrow. He asked whether the central bank's order flow communicates information about macroeconomic fundamentals. If the order flow is stochastic, he would argue that it does not. The authors had done other work that indicates that the order flow does contain information about fundamentals, but in this other paper, macroeconomic information explained

* Prepared by William Barker.

only about 20 per cent of the order flow. He estimated that an upper bound of the macroeconomic effect on order flow would be about 30 per cent. He said that the paper presented at this conference did argue for the effectiveness of portfolio-balance effects (as opposed to shifts in macroeconomic fundamentals), but that the case should not be overstated.

Finally, in regard to the comments on time-variant volatility of asset prices and risk-premium effects, he pointed out that the model assumes constant variance (and implies no shifts in risk premiums). They did not find any evidence of time-variable volatility, but this would be a suitable topic for further empirical analysis.

Lawrence Schembri addressed the issue of whether the order flow is picking up portfolio-balance effects or changes in macroeconomic fundamentals. He wondered if the authors had considered projecting (regressing) the order flow on the fundamentals and using the resulting orthogonal residuals in the model. Lyons responded that the data set used in the paper did not have enough observations—it was too short, at only fours years—to be able to do this effectively. He said, however, that there are now data sets available that are seven to eight years long and would allow this approach to work. He added that this was a good suggestion for future work.

Alain Chaboud asked Lyons whether he thought that the one-hour time frame the authors were using to define their data was too short to pick up inventory-adjustment effects, effects that may take longer to transact. Lyons said that they have lagged returns in the model, and that they do show persistence of adjustment. He noted, however, that adding a richer lag structure to pick up longer-term adjustments does not materially change the model's parameter estimates or conclusions.

Chaboud said that there are now extensive intervention data available from the Bank of Japan. He said that these data do not seem to show the magnitude of intervention effectiveness suggested by the paper's results. Lyons admitted that the Japanese data do appear to indicate less effective results for their intervention. This, he suggested, might be due to the strategy used by the Bank of Japan at the time. In particular, if a central bank reverses a previous portfolio shift, this will in turn reverse the effects of the previous intervention. The authors' results apply for a permanent shift in the central bank's balance sheet.

Chaboud asked whether, instead of defining the model in terms of "intervention," why not simply present it as a study of the persistence of order-flow effects? The type of intervention described in the model is now an "empty set": central banks don't use secret intervention any more, but rely on the signalling effect of their highly visible interventions to influence

the market. Lyons replied that the authors had limited their study to secret interventions, and the estimates cannot be directly applied to other, more visible intervention techniques. The results do show that if a central bank uses secret intervention, then the impact on foreign exchange markets should be approximately of the magnitude estimated.

Asani Sarkar noted that one piece of information missing in the model was the trade direction. He asked whether including this would have affected the results.

Lyons replied that although the data do not indicate the volume of trading or size of individual trades, they do show the direction of the trade (i.e., the data are signed either positive-one or negative-one, depending on whether the "aggressor" who initiated the trade was a buyer or a seller). He added that although it would be interesting to have more information about the size of each transaction, that information is not available. Nonetheless, he noted, they were still able to obtain useful results based on the information they did have on trade direction.

Discussion 1

John Chant

The topic of this year's conference was particularly appropriate given the award of the Nobel prize to three economists who have been recognized for their contributions to the treatment of information and its role in the economy. Before turning to the conference itself, I would like to reflect for a moment on the way in which economists treated information in the years BG—that is, the years before George Stigler, the first economist to receive the Nobel prize for economics of information.

For many, recognition of information costs was a reflection of market failure, not a recognition that real resources are required to produce, process, and transfer information among those who need it. This treatment was completely at odds with transportation costs. We recognized that it is costly to move productive inputs or goods and services from place to place and that businesses continually sought to minimize these costs. We also recognized that transport costs could prevent transactions from taking place, but that these transactions would be possible in the absence of transport costs. Interestingly, we never regarded such a possibility as a market failure. Rather, we viewed the economy as continually seeking the most efficient means of providing information. Transportation costs never gained the mythical status that often placed information costs outside economic analysis. Fortunately, economists have demystified them. We now study the ways in which the costs of information influence the way households and businesses act and the ways they organize their activities. This conference is especially welcome because it illustrates so vividly the ways in which the operations and organization of financial markets can be understood only from an appreciation of their role in the collecting, interpreting, and conveying of information.

Before going further, I would like to drive home the consequences of the information revolution in economics in a way that is particularly relevant today. At the early stages of the revolution, Grossman, Stiglitz, and Hart made the startling claim in a variety of papers, that free access to costly information could impair the workings of a market. They characterized information as being much like the public good of the fabled commons. If investors can free ride on the efforts of others in finding information, no one will be willing to seek out the information needed for efficient markets. A competitive information market could then resemble a frictionless world—imagine the chaos if we could not stop our cars, something everyone in Ottawa could easily envision. Of course, we might be saved by the fact that we could never start them either. A little bit of grit goes a long way in this world. Similarly, a little bit of grit permitting private access to information may go a long way in making financial markets work properly. But, as in the real world, all grit is not equal. Some can retard machinery and prevent its effective working, whereas other grit provides the traction that makes everything work. Much of this conference gives reality to these points.

My comments will address two issues: first, what is the nature of a central bank's stake in issues of financial structure and dynamics? Second, in what ways do the papers presented at this conference benefit central banks by providing better understanding related to their stake?

Let's look at a central bank's stake in financial structure and dynamics. The Bank of Canada, like many other central banks, is identified with two primary goals: the achievement of low, stable inflation and the maintenance of financial stability. An important common element of these goals is that central banks try to achieve them using market operations of one type or another. The quality of financial markets will affect the quality of the central bank's performance.

Without going into the transmission mechanism in great detail, monetary policy directed towards price stability works through the diffusion of the Bank's actions from the short-term financial markets, where the Bank operates, through to the markets that determine those longer-term interest rates and credit flows most relevant for the spending decisions of households and enterprises.

Well-functioning financial markets aid the working of monetary policy directed towards price stability in a number of ways. Less liquid financial markets are more likely to be subject to noise, requiring market participants to devote time and effort to distinguish the central bank's actions from that noise. To the extent that monetary actions change market fundamentals, the signals to market participants will be clearer and will permeate through markets more quickly when these markets function well. Effective financial

markets will also help to ensure that monetary policy is not targeted specifically towards any one sector over others. The generality of monetary policy is achieved by affecting expenditures everywhere in the economy according to their interest rate sensitivity. In the absence of a well-functioning market, this generality will not be achieved. Rather, monetary policy will bear more heavily on those gaining financing from markets that fail to operate smoothly in the face of changing monetary conditions.

In what ways have the papers of this conference contributed to an understanding of financial markets that would be helpful to central banks in carrying out monetary policy under normal conditions?

Markets are changing rapidly and will continue to do so. But there is a great difference between proclaiming change in financial markets and describing the ways they are changing and analyzing the implications of these changes. Here, the Domowitz paper made the important point that markets are not changing just through finding electronic means of doing things in the same ways that they are done now. It is the roles, as well as the modes of operation, of exchanges and brokers that are being radically redefined. Recognizing this is absolutely vital for central banks and regulators responsible for policies directed at markets. And it is important to keep it in context. Policy-makers must be concerned with the key functions of financial markets and how they are being performed. The restructuring of financial markets identified by Domowitz requires that policy-makers keep their eye on the functions and not be distracted by changes in packaging.

Increasingly, economists are attaching significance to the role of institutions to such a degree that it is often difficult to appreciate the difference that some make between theory and the study of institutions. Theory makes little sense without a context. Theory properly embedded in an appreciation of institutions and their structure can go a long way in helping to understand the subtle features of real-world institutions, and often these subtle differences matter. An appreciation of these differences leads to an important principle: be careful about altering institutions unless you understand them. This principle applies to many areas where economists were prone to identify inefficiencies in the functioning of markets, and for that matter, of governments and their agencies. This principle does not suggest that institutional arrangements should never be questioned. But it does reflect a simple lesson from George Stigler: survival may be an indicator of efficiency in an evolutionary environment. Enduring market arrangements have passed the test of time and should be given the benefit of the doubt even though some features many seem intuitively wrong.

Issues related to these principles were explored and illustrated during the first day of the conference. The difference in the order flow between equity

and fixed-income markets may appear rather insubstantial. Gravelle's paper on microstructure of dealerships suggests otherwise: current structures of equity and government securities markets appear to differ for good reasons. It is a fine illustration of the Grossman-Hart-Stiglitz principle about the consequences of excessive information. Existing market arrangements may preserve the value of information for market intermediaries and make possible their functioning in the market in ways that provide liquidity to other participants. The idea is taken further in the Audet, Gravelle, and Yang paper, which examines the underlying factors that favour different market structures. Both papers emphasize an appreciation that large, lumpy, infrequent order flows may require different institutions than fine, frequent ones. It will be interesting to see whether the extension of the paper's analysis can lead to the coexistence of the two types of markets under reasonable cost assumptions. The D'Souza and Lai paper develops a closely related theme by showing how changing the structure of market participants can change the workings of that market and alter the outcomes it produces. These papers use theory to make their points, but the points they make are not just theoretical possibilities—they are also empirically relevant.

The Madhavan, Porter, and Weaver paper examines a natural experiment that would clearly be conclusive and predictable—indeed one so obvious that many would not even bother considering it. The increase in the TSE's transparency arising from greater disclosure would surely improve liquidity of the market. Their findings to the contrary, however, lend great credibility to the theoretical work of the preceding papers. Holland's paper nicely rounds out this group by introducing a more practical dimension through a discussion of the choices faced by policy-makers when confronted by change. Standing still was not an option: the paper illustrates well the balancing of objectives undertaken by the U.K. authorities in dealing with change.

Let me now turn to a second objective of many central banks: the maintenance of financial stability. It too is supported by well-functioning markets. Such markets are more likely to digest changes in information without disruptions to trading or excessive swings in prices. Such markets are able, when under stress, to provide liquidity to market participants that lessens their need to be first out, reducing the prospects of runs that turn on such uncertainties. Problems of instability, therefore, seem less likely when markets are broad and deep.

The quality of markets affects the objective of financial stability in another important way. The effectiveness of the means at the disposal of central banks to overcome market instability—namely the provision of liquidity—depends on the quality of markets. This is well illustrated by the controversy

regarding the lender of last resort. Some argue that central banks can maintain financial stability by doing no more than supplying general liquidity to markets under stress. Institutions that are illiquid but solvent will escape their problems by gaining access to the greater general liquidity wherever it enters the market. Taken to its extreme, this position denies any distinction between insolvency and illiquidity. The inability to meet current claims is simply a sign of insolvency. Others, certainly much more numerous, believe that central banks must have the power to lend directly to troubled institutions to protect against and overcome financial instability. They believe that supplying general liquidity to markets may not be sufficient to preserve illiquid, yet solvent enterprises. The lending must be done directly if it is to reach troubled, yet solvent, firms.

These polar positions are derived from distinctly different views on the quality of markets. But there is another key dimension: the quality of markets at any time may not be a reliable indicator of their quality under stress. Just as financial instability is a low-frequency event, the relevant market conditions faced in dealing with financial instability are also low-frequency conditions. Here, the papers contributed useful knowledge for central bankers.

Contagion is a frequently used term and refers to the changes in the relationship among entities—institutions or countries—in times of stress. Yet it is not always clear what authors mean by the term. Surely it means something more than the fact that different economies or institutions are hit by the same forces at the same time. The Gravelle, Kichian, and Morley paper advanced our understanding of the issue by giving us a workable definition of contagion, and they demonstrated its usefulness for understanding the possibility of the international transmission of contagion in response to shocks. Similarly, the Furfine and Remolona paper shows that the response of financial markets to trading is different during periods of stress. Central bankers need to know that relationships that hold in normal times may not be dependable when markets are facing shocks. This research constitutes an early step in advancing our understanding of the way that market relationships respond under pressure.

The conference's final paper, by Evans and Lyons, bridges the two strands of analysis in the papers discussed so far, but is, in a sense, distinct from both. It is distinct in its motivation to examine the evidence for the portfolio-balance model of exchange rates, a macroeconomic issue, but it does so in a micromarket setting that has links with the papers dealing with market structure and its consequences. The authors model a two-stage trading process in the foreign exchange market where trading takes place at the first stage between dealers on the one hand and the public and central bank on

the other, and at the second stage exclusively between dealers. Attention is directed at the micromarket issue of how the trading process leads to two information effects: a purely intra-day effect reflecting the risk aversion of traders and an inter-day effect reflecting portfolio rebalancing by the other market participants. The paper links with the group of papers dealing with market responses under stress in its conclusion that the impact of order flows on markets, rather than being invariant, depends on market conditions, especially on the flow of macroeconomic announcements into the market.

In summary, what has this conference achieved? It has dealt with issues of vital concern to central banks in their roles as protector of price stability and guardian of financial stability. In doing so, it has provided a balanced mix of theoretical, empirical, and practical insights on critical issues that central bankers need to understand. There is one further dimension that I especially applaud: the conference has brought home the importance of micro-economic questions to the practice of central banking by showing that both the pattern of institutions that make up a market and the conditions within a market matter for the way that it responds to external forces. Central banks must be concerned not only with their levers of policy, but also with the linkages through which these policies shape the conditions and responses of financial markets.

Discussion 2

Dino Kos

I want to thank the Bank of Canada for inviting me to speak at this conference and also for their choice of topic. Many forums over the years have examined the macro aspects of financial markets, but less work has been done on the micro aspects. This is an area where much more work needs to be done, and this conference plays a very useful part in that process.

I will offer some general comments before focusing on particular issues. First, my observations are from the perspective of a practitioner, not an economist. Second, there is so much rich material here that I will not be commenting on it all, and in any case, I am fortunate to be following John Chant, who covered a lot of ground already. Instead, I want to focus on a couple of topics and in particular I want to talk about liquidity and why it is something that central banks should care about. Third, I want to congratulate the conference organizers for bringing together an impressive mix of the theoretical and the practical. Theoreticians and market practitioners sometimes have a difficult time talking to one another, but the dialogue dovetailed very nicely here.

At a conference like this, there are two things you can count on hearing from most attendees with regard to markets and central banking operations. First, the more transparent the marketplace, the better. And second, central banks are insufficiently transparent about their operations. So it was somewhat of a surprise that we had a paper asking whether securities markets should be transparent. That the question was raised at all was in itself novel. We then had a presentation suggesting that so-called secret, foreign exchange intervention, which has been derided in the academic literature for most of the last decade, could be a legitimate operational tool.

Let me talk a little about liquidity. I will start by looking at what it is, why it is important, and what can or should be done about it. I think of liquidity as the ability to transact reasonably large-sized orders at or near the current market rate. Related concepts used to examine market liquidity include bid-offer spreads, depth of market, and continuity of price. The way that I have defined liquidity says nothing about turnover, about how many dealers there are, or even what type of market is in play—whether a traditional physical exchange, an electronic marketplace, or dealer-driven, to take three examples.

I will look at why liquidity is important from the perspective of three groups of interested parties on the official side: (i) policy-makers responsible for managing the economy; (ii) regulators responsible for overseeing financial institutions; and (iii) central bank officials responsible for implementing decisions taken by policy-makers. First, for policy-makers taking the view from a broad, macro perspective, liquid markets are an integral part of risk transfer and the risk-distribution mechanism. It enables those who are unwilling to hold risks to transfer them to those who are, and it is one of the keys to achieving an efficient allocation of resources.

Second, from the regulators' perspective, as Jerry Goldstein from the Superintendent's Office succinctly explained yesterday, liquidity is the ability of regulated institutions, and even of those who aren't regulated, to fund themselves efficiently. I would add that it also includes their ability to change their risk profiles quickly in the derivatives or securities markets. From the perspective of regulators, liquidity is very institution-focused.

Third, for central banks actually implementing policy, I think that last night Governor Dodge elegantly described the importance of liquidity to central banks. Financial markets are how we implement monetary policy. A deep, liquid market that allows a central bank to expand or contract its balance sheet without disturbing asset-price relationships is important. We sometimes call this neutrality—we do not want to affect asset-price relationships by our own actions and thereby favour one group of issuers over another.

If we consider the Federal Reserve and other central banks ten years ago, the issues of what assets central banks should be buying and where there were deep, liquid markets did not even arise. Our governments were running large budget deficits and debt levels were rising, so there were lots of securities to buy and the markets tended to be quite liquid. Now we have a different situation. We have had surpluses, not only in the United States, Canada, and Australia, but in other OECD countries as well. A number of countries are actually paying down debt. But liquidity can be adversely affected by merely running smaller deficits. If the amount of money that needs to be invested, in aggregate, is increasing, and if the stock of government debt is

not increasing at the same rate, the proportional size of the risk-free asset is shrinking. That dynamic is even more acute in situations such as those in the United States and Canada, where the stock of debt is actually being paid down. At some point, the implications for liquidity and turnover in the markets have to be considered by the central bank.

If the ability to move seamlessly in and out of the government securities market is hindered, a central bank has to consider other possibilities. In most cases, the alternatives for central banks are not particularly attractive, especially if they have been accustomed to a very deep and liquid government securities market. To maintain a sovereign portfolio, one could buy foreign sovereign bonds. As I have said, however, many countries are paying down their debt and they would also have to face the foreign exchange risk. Alternatively, the central bank could buy other assets in the home country outside of the sovereign sector. But then, by definition, that means taking on greater credit risk, which would still result in less liquidity than in the past.

So what kinds of assets might one look at? They will vary from country to country and from situation to situation, but the possibilities include municipal debt, agency debt, mortgage-backed securities, and corporate debt. Each one has aspects that are not attractive in the sense of credit-risk characteristics, liquidity characteristics, tax aspects, etc. This means that the central bank must understand the liquidity characteristics of each market that much more as it makes its decisions about the future. Trade-offs between competing criteria—say creditworthiness and liquidity—are inevitable and choices will have to be made.

If you accept that at some point central banks may have to migrate to other markets, and that possibility has been considered seriously in many countries, then the importance of liquidity in markets for central banks is even greater. This leads to a question raised yesterday: if you accept that liquidity is important to the public sector, what can the public sector do to foster deep and liquid markets? In many ways, the best starting point is reflected in the Hippocratic Oath—do no harm. In other words, the public sector can start by removing obstacles that are currently holding back a fluid and flexible marketplace.

What kinds of obstacles am I talking about? Examples are legacy rules that inhibit turnover and liquidity, or more commonly, tax rules such as transaction taxes or withholding taxes that hinder trading or push it offshore. There may be legal barriers such as uncertainties about the status of contracts between counterparties. Public officials can help to alleviate this somewhat by fostering the development of master agreements that provide for legal certainty. Japan is a good example, where in the JGB (Japanese government bond) repo market there is a withholding tax that is being

eliminated and a new master agreement that is being developed. However, Japanese tax authorities are proposing a tax on certain cross-border repos, which would tend to impede transactions.

What are some positive steps that the public sector can take to enhance liquidity? In addition to a strong legal foundation, another important feature for deep and liquid markets is a robust clearing and settlement system. We can think of a number of examples where there were issues or problems with clearing and settlement systems. To the extent that these issues keep participants away because they can't be sure about the clearing, settlement, and custody of their securities, enhancing those systems may help.

If you have done all that and you have an open market, a sound legal structure, good settlement systems, and no other impediments, what more can one do? There may not be very much more that can be done. But we should keep in mind that—at least in my view—liquidity is not binary. It is not yes or no. It is constantly evolving and adjusting to the situation, the environment, and the profit opportunities in that market.

To use the U.S. government securities market as an example, in the mid-1980s, U.S. federal deficits ballooned, increasing the supply of debt. There was volatility in interest rates, volumes were increasing, as was liquidity. One could move large-sized trades at narrow spreads, and the profit opportunities were seen as attractive and plentiful. The number of primary dealers grew to at least 45. In the last few years, we have had a different environment, with decreasing debt supply. The profit opportunities have also changed. We have had some entries and exits from the primary dealer ranks, but the reduction of the number of primary dealers comes from consolidation; the list is now down to about 24. One commentator suggested that the number of primary dealers has adjusted to reflect the current level of profit opportunity. Has liquidity declined? One can certainly say that the nature of the liquidity has changed. Large sizes can still be moved in that market. However, capacity has adjusted to a new quantity of risk that needed to be transferred, as well as to the improved technology, which has increased productivity among the dealers.

I think my message here is that it's very difficult, from the public sector perspective, to manage and foster an increase in liquidity once you have taken away all of the obstacles that may have hindered development of the market. The market has to—and does—find its own level of liquidity, even though the process does not always appear smooth when we are going through it.

In my remaining time, let me say a few words about the very interesting discussion this morning on stress in markets and contagion. A lot of work has been done in the public sector, at the IMF and the BIS, and in academia in identifying contagion and finding ways to prevent it. That is a very tall order and I don't quite know how one goes about doing so. In part, that is because there are various forms of contagion. Many of the ideas to counter contagion involve constricting how markets work, which, in turn, may affect financing to emerging markets. But it does help to understand the processes. If one country is the object of a shock right after a neighbouring country experienced a similar shock, it is useful to know whether the country has internal problems that justify the new perception, or whether the second country has been thrown into the same lot, as investors shoot first and ask questions later. The answer to that question is important because it may influence policy choices. But that is still different from preventing contagion ex ante, which is very difficult.

Does that mean that nothing can be done? I would say no. We can do something to foster strong financial intermediaries and a strong financial sector. One of the messages of 1998, when we had tens of billions of dollars of losses that were spread around the global financial system, was that you had a system that actually held up rather well given the stress that it was under. Again, I want to emphasize that with the losses that were distributed to the major intermediaries in the global financial system, the fact that the system held up as well as it did is very positive. But that was only possible because we have institutions that were very well capitalized and that were able to absorb a hit.

In contrast, the late 1980s and early 1990s saw the United States in recession; we faced the headwind caused by a credit crunch, because financial institutions were simply not as strong at that time. In other words, if you accept my notion that contagion is difficult to prevent, then you must have a market infrastructure that is sufficiently robust to absorb the stresses that may happen upon it.

Discussion 3

Richard K. Lyons

I enjoyed the conference immensely, and for me it has highlighted the idea that two gestalts were brought together, one micro and the other macro. In a broader context, there remains a micro/macro disconnect, which is evident even in my own thinking. For example, because I come from a macro tradition, when I hear terms like "microstructure effects," I still think "short-lived," not resource-relevant—not things that macro people need to think about. And I think this way despite having worked in microstructure a long time.

One thing that is shifting focus away from microstructure "effects" and towards a notion of microstructure as "tools" is that we are thinking a little differently about information economics. Macro people are beginning to appreciate that there is a different way of approaching certain issues that may be relevant at both the macro and micro policy levels. Bridging that disconnect is, for me, one of the most enriching things in a program like this.

Consider the literature on the 1987 stock market crash. Most macroeconomists believe that was a significant event. If you look at research done on the crash, at the work of someone like David Romer, a macroeconomist, and of people like Hayne Leland and Sandy Grossman, the models they used were microstructure models. That is, the literature chose microstructure models as vehicles for understanding a very large macro event. The contagion models in our discussion here were also addressing macro events with microstructure tools.

An important conclusion from this is that microstructure models can help us re-evaluate the nature of underlying information environments. Is it an environment of dispersed information, or can we rely on common knowledge paradigms and feel comfortable about them? I believe that these tools are helpful for that sort of thing.

I have split the remainder of my remarks into two parts. The first focuses on policy issues and the second portion concerns research suggested by some of the conference discussions.

Policy point one: Electronic trading has facilitated the collection and integration of data. This should be encouraged.

During the conference, we heard about the concept of reintermediation. I think that was very helpful. Beyond reintermediation, electronic trading has given us access to data. Many of the stories that were told today about order flow driving price and so forth have been going on a long time. But now, because many of these electronic platforms have given us complete archives of what is transpiring inside the black box, we can capture much of the essence. We can measure and evaluate the phenomenon at its source. Consequently, policy-makers might begin to recognize that these types of data exist, and although we haven't traditionally thought about capturing them, policy-makers might start encouraging institutions to do so and to share that data when the incentives are right. More importantly, they might encourage the integration of different types of data. In the foreign exchange market, I have said that the order-flow pie has three pieces (customer-dealer trades, direct interdealer trades, and brokered interdealer trades). Today I discussed one of those pieces. It's as though we are groping at the elephant but we have only identified a small part of it. Therefore, data collection and integration are things that official institutions might help with considerably.

Policy point two: Who owns price?

Who owns order flow? This is not the way we used to think about quantities and prices. Traditionally, quantity and price are not intellectual property. Yet they are very much so in the sense that property rights can be maintained and legislated. I'm not saying that these rights should necessarily be legislated. But who owns price and order-flow information is a legitimate question. Let me give you an analogy. Some of my faculty colleagues who do research in marketing say, "Hey, you should have seen what happened to us on the empirical side when we got hold of scanner data." When you go to the grocery store, scanner data can reveal what you bought, what you bought it with, whether you have kids, how you paid for it, what time of day you shop, and so on. Who owns that information? Lots of institutions collect that information and sell it. Do we think twice about that? Do you say, "Wait, there is value here—shouldn't I own a piece of it, or do they own it?" When a customer trades with a financial institution, who owns the order-flow

information? This is an important property rights question, and I don't think that people have given it enough thought.

Policy point three: Information is an important and growing driver in business.

The intellectual property perspective is changing the way industries are aligned and how they do business. For example, we recently taught an executive program at Berkeley, and I was talking about order flow and how order-flow information is valuable. A fellow who works for Goldman Sachs came up to me and said, "We just bought a company called Spear, Leeds, not because we wanted to be in the transaction business [Spear, Leeds & Kellogg is a market-making company], but because we wanted their order-flow information." That is a remarkable way of thinking about why a merger might create synergy: one institution has price or order-flow information that another institution can exploit. Though this is changing consolidation patterns within the industry, it is not the way we have traditionally thought about consolidation. This issue arose in a number of papers, and I think that the "informational" driver is significant now, more so than it ever has been.

Policy point four: The role of transparency

Transparency has been a big issue at this conference and rightly so. It has many dimensions. Ananth Madhavan's paper (with co-authors Porter and Weaver) focused on pre- and post-trade price information. That is, do I get to see the price before we trade? Why Goldman Sachs might buy Spear, Leeds is related to quantity information post-trade—who owns it and who sees it. One point that was made with respect to the order-handling rules in the equity markets, in particular the over-the-counter equity markets in the United States, was that the big change in order-handling rules in 1997 that Ian Domowitz spoke about was a watershed for the ECNs (electronic communication networks). That rule essentially said that when a broker receives a limit order from a customer, it must show that limit order to the market. The broker can't simply hold the order and use discretion as to what constitutes best execution.

As for foreign exchange (and bond markets), one can think about transparency in these markets in two different ways. First, when a bank has seen all of its order flow and the consummated trades that it has done with its customers, it might be able to use that information to forecast market movements. The second way involves pre-trade information: in any bank's trading room, the spot traders have all the customer limit orders on screen. If you could take all those limit orders that are waiting to be traded and aggregate

them across the market, you would have an aggregated limit-order book (pre-trade quantity information). That is precisely the kind of information that the order-handling rules were designed to address on the over-the-counter equity markets, and few people have thought very much about whether order-handling rules would be a good idea in foreign exchange. There are many sound arguments why full transparency might not be a good idea. But let us also consider dimensions of the transparency question that we haven't addressed yet, for example, the pre-trade quantity information in foreign exchange markets. It's not even on the policy radar screen yet. And again, I don't want to propose that it should be regulated or disclosed. I am simply saying that there is an issue here that hasn't been considered to any great extent.

Policy point five: Market microstructure can be useful for market design purposes.

A number of the papers touched on this point. Official institutions such as the IMF often go to countries where the questions are, "Should I have a forward market in foreign exchange? Would it be stabilizing?" Microstructure theory can help us resolve such questions. If a policy-maker argues that introducing forwards and futures would be destabilizing, microstructure offers a disciplined way of saying, "here is what the theory says." If these conditions hold, then introducing the market might indeed be destabilizing. If these conditions do not hold, then it is not likely to be destabilizing. There is a strong literature for thinking about these issues. The market design dimension (particularly in emerging markets) of much of what was discussed is rife with policy implications and potential applications.

Research point one: What are market-making services?

When we talk about institution design from a traditional microstructure perspective, we typically think about asymmetric information or sharing of market risk and how the two mix. That is largely what microstructure theory is about. One of the things that arose yesterday was that one reason we might have a dealer market in foreign exchange or fixed income is because, for example, IBM does not want to take direct counterparty credit risk with GM. They do not want to consummate a trade directly with GM because they are worried about the settlement or default risk in that direct transaction. So when one asks why we have intermediaries rather than an open, electronic limit-order book where the GMs and IBMs can trade together, the answer that seemed to come out of that discussion is that the service being provided by the market-maker is not a transactional one.

Instead, it is an ability to be the middle person in a transaction that has default risk. If you gave IBM and GM an opportunity to trade directly with one another, they would choose not to do so. That suggests that we have a dealer market structure, not because of market risk-sharing properties or asymmetric information properties, but because of credit-risk management. Microstructure theory has never really considered this, and it is an interesting way of thinking about how we unbundle what dealer markets (or any other type of market) provide. We begin to distinguish features—and they may be the driving features—that were not in our traditional theory.

Research point two: What is the information?

The term "order-flow information" is not particularly clear or helpful. Every microstructure model would say that order flow is the vehicle that conveys information. But what is the information that motivates those orders? Much of the empirical research on fixed income, equity, and foreign exchange markets says that order flow is indeed a proximate driver of price. But what drives the order flow? One could argue, "You haven't taught me anything because order flow is so close to price that I haven't really learned anything. You have to tell me what precedes order flow."

One of the strategies for answering this question starts with the fact that order flow can be disaggregated. Does the flow of non-financial corporations and financial corporations have the same price impact, dollar for dollar? The answer is that in foreign exchange these order flows do *not* have the same price impact. That tells us that the underlying information structure is not just homogenous, undifferentiated demand. There is different information potency in different orders, which reveals something about the underlying information structure that we didn't know before. It does not pin down the information precisely, but it does help us understand where it is located, and it may establish a new starting point from which we can understand more fully.

Another strategy for pinning down the information in order flow is to think about price at time t as being a function of fundamentals at time t plus expected future fundamentals at time $t + 1$. If one is considering an equity, one could think of these fundamentals as current earnings and expected future earnings, respectively, or, in foreign exchange, as the current interest rate (or current monetary fundamentals) and expected future interest rates. Order flow may be communicating in real time the way the market learns about variations in market expectations of future fundamentals. After all, in asset pricing, expected future fundamentals are the name of the game, and variations in these fundamentals are obviously not common knowledge.

Research point three: What is the role of order flow in impounding information into prices?

If you are thinking about equities, consider earnings announcements, or in foreign exchange, consider macro news announcements. We might ask whether announcement information is going directly into prices, in which case you don't need order flow to move prices. Or perhaps order flow is helping us to reconcile differential interpretations of common data. I believe the answer is the latter. Preliminary results suggest that order flow is even more important to price determination when public data are being thrown at the market, because people interpret that data differently. This suggests that they are using different models. In any event, this is the kind of thing that this type of analysis can help us understand.

Research point four: Are there market failures in informational investment?

We often think about transparency in a context where there is a given amount of information. But does that information get into price more quickly if markets are more transparent? The informational investment perspective says, "No, wait a minute. There is a previous decision that had to be made." If I need to invest in gathering information and the market is so transparent that I cannot execute a trade before price reflects my information, then I am not going to make the initial information investment. In that case, the highly transparent trading process may impound *less* information in price because people are doing less information investment upstream. This is a very important idea, and when we think about transparency and information gathering, we need to consider the informational investment decision.

Research point five: Are there multiple equilibria in liquidity?

I want to talk about liquidity and some of the ideas that have emerged in many of the papers. We had a discussion at lunch, for example, that may be far-fetched, but the basic notion did come out of the ideas of the conference. The Canadian government issues index-linked bonds, which are purchased at auction, but there is very little secondary market trading. The suggestion was that maybe the price that these bonds are issued at is lower than it should be because they are not very liquid (because people aren't trading them). If it were a more liquid market, who would benefit? Certainly the

Canadian government would: it could issue paper at higher prices and thereby lower its borrowing costs.

Here's a simple model. Suppose there are two customer segments. One segment is buy-and-hold and it wants index-linked bonds for a portfolio. The second is a trading segment that may not want to become involved in auctions of index-linked bonds because liquidity in the after-market (the secondary market) is too low. We are caught in an equilibrium where only one of the segments is bidding. If we wanted to shift to a different equilibrium in which both are participating, the central bank could provide liquidity in the after-market to draw in the second customer segment. That second customer segment would then obviously start bidding more at auctions and so forth, which would increase prices.

Why wouldn't a private market participant provide that liquidity? Where is the market failure? The market failure is that the government can internalize the benefit of higher bond prices. It is willing to do the market-making operation because it internalizes the externality of higher bond prices. A private sector market-marker would not be willing to provide that liquidity; only the first of those two customer segments would show up at the auction. I offer this liquidity story as a means of understanding why liquidity might have multiple sticky states. This is a topic that is relevant and that warrants further examination.

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